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HENRY HORNER, Governor

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PAPERS IN AGRICULTURE

EXTRACT FROM THE REPORT OF THE SECRETARY

No formal program was announced for the Agriculture Section. A brief session was nevertheless held at which the following two papers were presented.

Preliminary Studies in Milk, by Robert J. Walker, Illinois State Normal University, Normal.

Homogenized Milk, by Milton H. Dunk, Illinois State Normal University, Normal.

C. W. Hudelson, 206 South Main Street, Normal, Illinois, was elected chairman of the Agriculture Section for the 1937 meeting.

(Signed) W. M. LUCE, *Secretary*

Preliminary Studies in Milk

Robert J. Walker and Milton R. Dunk
Illinois State Normal University, Normal, Illinois

This work was carried on in the bacteriology laboratories of Illinois State Normal University. The experiments were performed as class work in a course of General Bacteriology under the instruction of Dr. Lamkey.

The experiments for the most part are concerned with the size of the fat globules and their relation to the digestibility of milk. The fat globules of viscolized and ordinary milk were measured by diluting the milk and placing a drop on a hanging drop slide and then measuring with the micrometer eye piece in a miscroscope. From our measurements we found that the viscolizing process reduced the size of the fat globules eight times. Milk that had been standardized at 4 per cent butter fat and then viscolized was tested for butter fat content and the viscolizing process was found to have no effect on the butter fat content.

Next, samples of viscolized and ordinary milk were plated out to get the bacterial count of the respective milks. To do this, 1 c.c. of the milk was placed in 1000 c.c. of sterile water. Then ½ c.c. of the water was plated out in litmus agar. One c.c. of water was also plated out in litmus agar. Viscolized milk has a higher bacterial count than unviscolized milk. This fact was to be expected because the more times the milk is handled after pasteurization the greater the chance for contamination. The viscolization process is carried on after pasteurization. It is also possible that the viscolization had broken the bacterial clumps into various parts and that these parts had resulted in a higher count. Other counts were made on other samples of milk and the above results were borne out.

Digestion tests were then performed on the milks. Steapsin was the enzyme used and 5 per cent solution of litmus was the indicator.

(I) 50 c.c. of viscolized milk + 750 m.g. of steapsin boiled.
50 c.c. of viscolized milk + 750 m.g. of steapsin.
(II) 50 c.c. of pasteurized milk + 750 m.g. of steapsin boiled.
50 c.c. of pasteurized milk + 750 m.g. of steapsin.

The milk was heated to body temperature and the steapsin that had been dissolved in 5 c.c. of water was added. Four c.c. of 5 per cent solution of litmus was also added to each sample.

To one sample of viscolized milk boiled steapsin was added. The boiling killed the action of the enzyme.

To one sample of viscolized milk unboiled steapsin was added.

To one sample of ordinary milk boiled steapsin was added.

To one sample of ordinary milk unboiled steapsin was added.

The boiled samples were checks on the action of the steapsin in the milks. The boiled samples also indicated that it was not formation

of lactic acid [souring process] that changed the litmus from blue to red. A known standard of red was used as the end-point in the digestion. When the litmus had changed to the standard red the experiment was ended. We had no way of testing for completeness of digestion but were only testing for rapidity of digestion. The viscolized milk turned the litmus to the red standard in ⅓ of the time it took for ordinary milk to change the color of litmus. The steapsin digested the fat, forming fatty acids and glycerine. The fatty acids changed the litmus from blue to red.

We have run many digestion experiments with viscolized and ordinary milk and have found that the steapsin digests the viscolized milk three times faster than ordinary pasteurized milk.

Our next experiment was the comparing of the size of fat globules of Holstein and Guernsey milk and testing the rate of digestion of Holstein and Guernsey milk.

Representative samples of Holstein and Guernsey milk were diluted with water, placed on a hanging drop slide, and examined under the microscope. The size of the fat globules was measured with the micrometer eye piece of a microscope. The average size of the fat globules of Holstein milk was 6.7 microns. The average size fat globule of Guernsey milk was 7.7 microns. The Holstein had the smallest fat globule by about one micron or the fat globules of the Guernsey were 12 per cent larger than the fat globules of the Holstein milk.

In the digestion tests of Holstein and Guernsey milk, each test contained the following: 50 c.c. samples of milk; 750 m.g. of steapsin; 4 c.c. of 5 per cent litmus or 20 drops brom cresol green.

The milk used was composite samples of raw whole Holstein and Guernsey milk. The pH of the two milks were determined and found to be the same: a pH of 6.3 or slightly acid. Half of the milk was pasteurized at 60° C. for 20 minutes and the other half was left raw.

	Milk	*Condition*	*Indicator*
(I)	Holstein	Raw	Litmus
	Guernsey	Raw	Litmus
(II)	Holstein	Pasteurized	Litmus
	Guernsey	Pasteurized	Litmus
(III)	Holstein	Raw	Brom cresol green
	Guernsey	Raw	Brom cresol green

As in the case of the other digestion tests, an end-point was set for the color changes of the indicators. Again we were testing not for complete digestion but for rapidity of digestion. The samples were kept in an incubator while the experiment was in process, the temperature being 37½° C. No appreciable difference was found in the time it took Holstein and Guernsey milk to digest. On a check experiment the same results were obtained. However, not enough tests have been made to draw definite conclusions as to the qualities of digestibility of the two milks.

PAPERS IN ANTHROPOLOGY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The program of the Anthropology Section carried fourteen papers, nine of which are here represented. The others are:

Some Anthropological Aspects of Western Illinois, by O. D. Thurber, Senior High School, Quincy.

A Cache of Unusual Flint Blades, by Frank W. Aldrich, Bloomington.

Deformation of the Mound Builders Skulls, by John F. Barrett, University of Illinois, Urbana.

Anthropology of Western Illinois, by W. C. Williams, Pittsfield.

Rock Carvings in Southern Illinois, by Bruce Merwin, Southern Illinois State Normal University, Carbondale.

The meeting was well attended.

The present chairman, Dr. J. B. Ruyle, 9 Main Street, Champaign, Illinois, was reelected chairman of the Anthropology Section for the 1937 meeting.

(Signed) J. B. RUYLE, *Chairman*

Evidences of Woodland Culture at Mossville

F. L. Barloga

Peoria Academy of Science, Peoria, Illinois

The village site described in this paper is located one mile due west of the village of Mossville in Peoria County, Illinois (Fig. 1). A gravel highway passes through the village site at the present time. Three branches of a small spring converge in the center of the campsite, the resultant larger stream flows to the Illinois River about 1¼ miles to the east. The site covers about five acres and is on the west edge of the Illinois River terrace. At this point hills rise sharply to an approximate height of 200 feet.

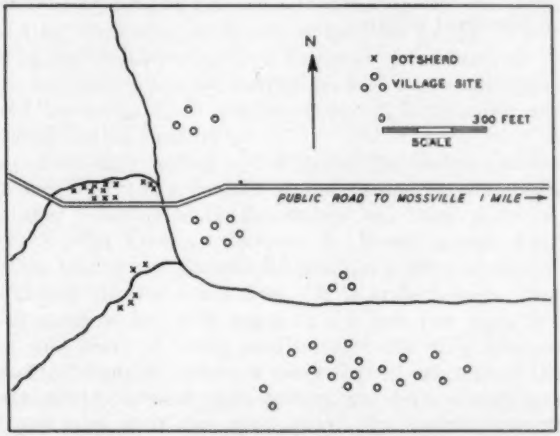

Fig. 1.—Sketch map showing location of village site near Mossville.

A workshop site about 1000 feet south of the main stream was discovered while the owner was planting apple trees. Most of the artifacts (shown on the slides) were found on the workshop site. Several hundred broken points and scrapers were found.

All pottery sherds excavated to date have been found on the south side of the middle or west fork of the stream and on either side of the south fork. No sherds have been excavated along the main stream or the north fork. Eleven pots have been reconstructed from the sherds,

most of which had crenulated lips inside and out. The sherds were plain, cord impressed, rouletted, or stamped. All potsherds were grit-tempered and were excavated from a depth of 3 to 5 feet below the present surface, the original surface having been from 2 to 4 feet below present surface. The wash from the hills on the west edge of the camp-site has made this deposit since the time of the early inhabitants.

Bones, shells and miscellaneous items were found in addition to potsherds. The clam shells were from the Illinois River perhaps but the origin of the shell beads is less easy to determine. Bones were of deer, wapiti, dog, beaver, and fish. Near a disturbed childs skeleton were two piles of clam shells, 47 in one pile and 85 in the other. In the second pile it was interesting to note that all of the 85 shells were left valves. In addition to the shells two small triangular points and a small smooth piece of galena were found. A monitor pipe was found on a subfloor and a semitublar pipe lay beneath a large crushed bowl. No storage pits have been found but many firepits with contents of charcoal and burnt shell have been unearthed.

The location of the site, the type of pottery, the lack of storage pits and the fact that the great majority of tools are of stone, indicate quite strongly a Woodland culture.

Archaeology of Western Kentucky

Fain W. King
Wickliffe, Kentucky

That portion of Kentucky called the western part is more often called the "Purchase", due to the fact that this territory was purchased by Jackson one hundred and eighteen years ago from the Chickasaw Indians for $300,000, including eight counties in Kentucky and twenty counties in Tennessee. General Jackson reached an agreement with Chief Paduke, head of the Chicasaws and after whom the city of Paducah is named, in October, 1818, in the year 1819 January, the contract was ratified by Congress, the same year saw the Chicasaw Indians trek southward and the pioneers pushing into the new territory. The "Jackson Puchase" is completely surrounded on three sides by water, bounded on the east by the Tennessee River, on the west by the Mississippi, on the north by the Ohio River, and on the south by the State of Tennessee. Due to the fact that this entire district has such a great mileage of rivers within and bordering it, to use the words of Funkhouser and Webb, "It was Good Indian Country".

Many of the early reports of Collins and Rafinesque, also the reports of Miller and Weir, list a number of Indian sites in western Kentucky and a number investigated in McCracken and other parts of western Kentucky are well known. Clarence B. Moore reports for 1915-16, Philadelphia Academy of Natural Science, list much work done in actual excavations and also list other sites. It is evident from these reports that much progress has been made in the last few years in method, technique, and study of living conditions of the early groups. Moore in his report of finds in Arkansas states that in one mound they found about six hundred pieces of plain pottery, but did not wish to keep this material and most of it was given away. In studying reports of the early Archaeologists one is forced to come to the conclusion that most of the work was done to secure artifacts and the important part of the story was overlooked as being of very little interest. In recent years the artifacts have ceased to be paramount, the story in the soil is being searched out with the aid of various branches of science, botany, chemistry, zoology, geology and tree-ring study.

The work of Funkhouser and Webb of the University of Kentucky, at Tolu, Crittenden County, on the Ohio River, also work of excavating elsewhere in the state indicates great improvement over the earlier work. The work of Dr. Cole of the University of Chicago, just across the river from Paducah, in Illinois, is a model of method and perfection

from the standpoint of present knowledge and experience. The Kincaid site, as this is known, although in Illinois is showing from the two seasons work much in common to the cultures in western Kentucky.

Probably the best known mounds in the Mississippi Valley are those located at Wickliffe, Kentucky, due no doubt to the fact that the find is unusual and also that the material is left in situ, likewise the great extent of the work done and yet to do. Each season work is carried on in actual excavating, all the year work is going on in research of some kind. This work is open to the public at all times and has had much to do with acquainting the great masses with Mississippi Valley Archaeology.

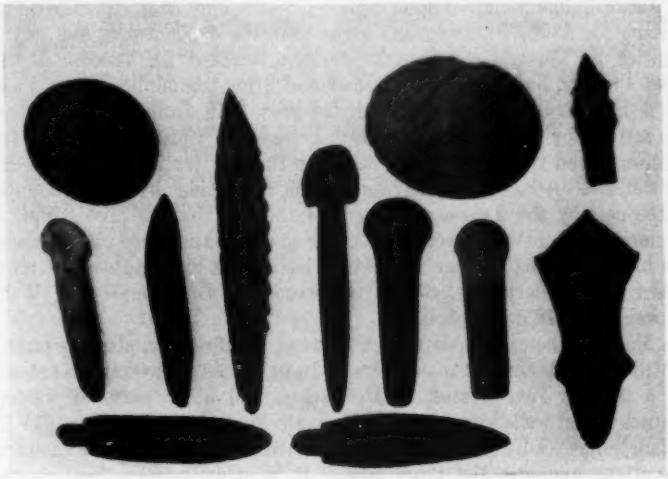

Fig. 1.—RARE AND UNUSUAL FLINT AND STONE CEREMONIALS.

Within the city limits of Wickliffe, on a high bluff over looking the meeting point of the Mississippi and Ohio rivers is the remains of what once was the most important center for trade, commerce and religion in this district. On this natural fortification, which commands both rivers, are located nine mounds and kitchen midden to the depth of several feet over more than twenty-five acres. Work has been in progress more than three years and it is estimated that it will take four or five years to complete this investigation.

At the present time we are working on Mound D which will be known as the infant burial mound as we have to date found fifty-two infants; four adults were found at higher levels and only one half of the mound has been uncovered to date. The universal five-foot square method is being used with floor plan showing location and material, and vertical cross-section showing the stratigraphy. This mound has differed

in that it is made of kitchen midden no doubt scraped from the surface near by, built in stages to a height of about seven feet and a length of 170 feet. The other three mounds excavated to date are composed of almost sterile soil, each basket load of earth showing but little bone or broken pottery. Sherds from one 15-foot cross-section of Mound D filled several very large boxes which were sent to Dr. Guthe, U. S. Repository for Broken Pottery, and an even larger amount from an other section was sent to the University of Chicago for study in Dr. Cole's work. Great quantities of bone material of animals and fish have been recovered.

This will enable us to give a very grafic picture of the kinds and amounts of food consumed over the period of the construction of this mound. The sherd count per foot is showing some very interesting facts for comparison.

Fig. 2.—Group adult burial with pottery, shell, and other artifacts.

Each mound opened to date has differed from the others. Mound A shows two burned buildings at two levels with dirt apparently thrown on the buildings while they were in the process of being burned after they had collapsed. Three altars, hard burned, connected, were uncovered in the upper building with offerings near by. The cane and charred material is well preserved. Tree-ring work was conducted by Dr. Hawley during one season but is not complete. This mound is called the Temple Mound because its contents are religious or ceremonial.

Mound B proved to be interesting as at the base we found the complete outline of a building indicated by post-molds, doorway, and loose earth just outside of the line of post-holes indicating a drainage ditch. Three circular fire places were located at the floor level, two of which were only four inches apart, and the third thirty inches away from the other two. Nine pieces of pottery, two bone turkey callers, and a bushel of very small undeveloped corn cobs that had been reduced to charcoal

were encountered in the first test. Very few artifacts were found elsewhere. This mound is called the Council House Mound as the building is twenty-one by twenty-five feet in size and would indicate a shaman's or Chief's building or a building where council was held.

Mound C has been excavated to one tenth of its contents from measurements and test holes. One hundred fifty-three burials with pottery, bone implements, copper ornaments, flake mica, lead and hematite fashioned into various shapes are in place as uncovered. Some very interesting burials were disclosed. One no doubt represented the leather worker, as with the burial were a number of bone implements of various sizes and types used for working leather. In an other place we found the pottery maker, for at the head of this female were six pottery trowels, a small piece of coal shaped to a fine edge, and a gravel also of the same general shape. In one group we have male, female, and a small infant, no doubt a family group. In another place is a twin burial, and in another an old woman who had lost all of her teeth prior to her death. In all a very interesting group of burials.

Preliminary Factors in the Use of Tree Rings to Date Mounds of the Mississippi Valley

Kenneth L. Knight

Illinois State Normal University, Normal, Illinois

The talkative tree rings have revealed knowledge to science that was supposed to have perished long centuries ago. By the use of the annual weather records so reliably kept by the trees, man has pushed the historical horizon of the Southwest back nearly eight centuries before Columbus discovered America, a time comparable in European history to the reign of Charlemagne.

This enlargement of our historical concept was accomplished by Dr. A. E. Douglass[1] of the University of Arizona. Dr. Douglass, who is an accomplished astronomer, originally began a study of tree rings in an effort to see if sun-spot periodicity had any effect upon the climatic conditions of our earth, which in turn would supposedly have an effect upon the yearly growth of the trees. This work progressed most satisfactorily and he soon became convinced that sun-spot periods could be traced out in the tree rings. To get large series of tree rings he began using ancient timbers from the pueblo ruins of the Southwest and from there it was only a step to the application of his tree ring calendar to archaeology. Through the use of this calendar nearly every ruin of importance in the West has since been dated.

Ever since this monumental work by Douglas appeared, the thought of applying a tree-ring chronology to the dating of the Mississippi Valley mounds has intrigued archaeologists.

Because the climate of the Mississippi Valley differs so widely from that of the West, it is absolutely imperative that we find out the exact influence which this climate has on tree growth. That is, has the amount of growth for each year been dependent enought on one specific factor, for example, precipitation, that it will be characteristic for the trees of that one region? If such a condition does not exist, then it will be impossible to set up a tree-ring chronology.

As yet no work has been published on this subject for the Illinois region. However, in 1935, Diller[2] published some positive data and conclusions concerning the correlation of tree ring width to temperature and precipitation for a series of beech-maple woodlands in northern Indiana. Some work by Lyons[3] in 1935 for the New England area, shows that a similiar conclusion may be drawn from that region.

With a desire to help in this regional study of factors controlling tree growth, I have done some work in central Illinois which I believe may be used in interpreting the general conditions existing throughout this portion of the Mississippi Valley.

In my work, sections were taken of three elm stumps from north of Normal, Illinois. The trees were selected with careful consideration

being given to all ecological factors which might interfere with the records kept by the trees. There are a number of such factors which may influence the amount of a tree's annual growth so that the dendrologist must constantly be on the alert for errors in his data.

For the sections from each stump, the width of each of the yearly growth rings was measured and recorded. The widths of all of the rings for each tree were then averaged; and to put each tree on a common basis with the others, the percentage deviation from the average was calculated for each ring. The next step was that of averaging the three percentage deviations for each year represented, and then plotting these averages on coordinate paper. To correlate this record with precipitation, it was necessary to secure a set of official rainfall measurements from the nearest weather bureau station which happened to be the Peoria station about sixty miles away. The rainfall yearly totals for each of the years represented by tree-ring records were then reduced to percentage deviations from the normal and plotted beside the tree-ring line on coordinate paper.

The conclusions drawn from this study are: that the two lines, one representing rainfall and the other tree-ring growth, correlate very definitely in the positions of their extreme highs and lows. That is, an extremely heavy yearly rainfall is coexistent with a noticeable increase in tree growth and vice versa. Moreover, the work of Diller was corroborated by the observation that, in general, drought years had their greatest effect upon the tree growth for the succeeding year; while extremely wet years affected the tree-ring growth of the same year.

These data very definitely show that tree-ring growth is due to some common factor which will make possible the recognition of a specific year through a series of trees over a comparatively wide area. In turn this fact makes it possible to set up a tree-ring chronology through which a mound may be dated by the fragments of wood or charcoal found there.

Recently the University of Chicago under the direction of Dr. Fay-Cooper Cole has begun such a task in the Mississippi Valley. Practically all of the research is being carried on in the region covered by the Tennessee Valley Authority. A letter from Dr. Cole states that a great deal of material has been assembled and is being worked up. However, none of this has been released up to date because Dr. Douglass, who has charge of the releasing of all such material, feels that the series for this region were not sufficiently long to justify a statement. However, we may look forward to some very interesting developments in the near future. It will certainly be a mile-stone in American archaeology when the dates are known for some of our Mississippi Valley mounds.

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Indian Camp Sites Along the Mackinaw River Near State Route 51

C. W. Hudelson

Illinois State Normal University, Normal, Illinois

For the past fifteen years the writer has followed the hobby of hunting over Indian camp sites during the late fall and early spring in search of Indian artifacts or other evidences of Indian habitation. This paper describes briefly those camp sites found along the Mackinaw

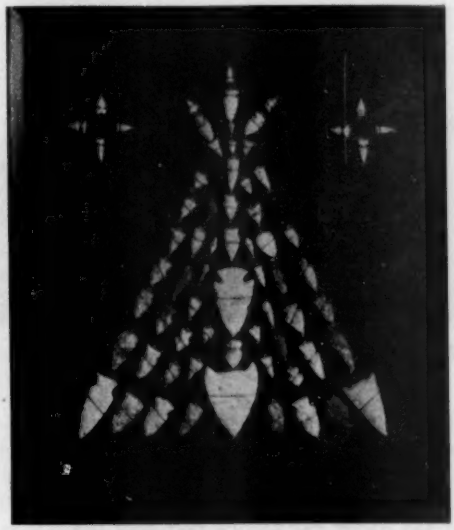

Fig. 1.—Arrowheads from camp site along Six-Mile Creek.

River within a range of five miles on either side of State Route 51. In this region Route 51 extends north-south except for a slight curve on the north side of the river. The Mackinaw River flows in a westerly direction over the entire ten mile stretch except for a number of short curves.

The area includes two northwest-flowing tributaries that enter the Mackinaw from the south and along which a number of camp sites have been found. The larger tributary, called Money Creek, lies about three

miles east of Route 51. A few years ago the city of Bloomington constructed a dam across this creek to create Lake Bloomington as a source for city water. The various activities and enterprises which followed, such as the building of the pumping plant, settling reservoir, and dwelling houses, and the general rise of water in the valley to form the lake, obliterated a number of camp sites. The smaller tributary, called Six-Mile Creek, lies on the west side of Route 51 and flows into the Mackinaw River about two and a half miles west of the bridge on Route 51. According to pioneer reports and records, the Potawatomie Indians made their last stand against the white men in this region along Six Mile Creek approximately one mile northwest of the present village of Hudson. In 1920, an engraved boulder was erected as a memorial to this

Fig. 2.—View of one of the camp sites (foreground) in the Mackinaw River region.

struggle by the Letitia Green Stevenson Chapter of D. A. R. of Bloomington, Illinois, on what is now Route 51 at the cross-roads intersection about half a mile, west of Hudson. Six Mile Creek flows within about one hundred yards of this boulder. Downstream and within two miles of the boulder the writer has hunted over four camp sites a number of times and has found approximately two hundred arrowheads and spearheads, as well as a number of other artifacts. Seventy of the arrowheads and spearheads are shown in figure 1.

The river valley ranges in width from about one-quarter of a mile to nearly one mile in some places. The stream itself in normal times often ranges from 30 to 75 feet in width. The Indians located practically all of their camp sites on a point of ground having good drainage and on a little higher elevation than the surrounding land, out of danger of flood and with a commanding view of the possible approach of their enemies from all sides. They were, however, reasonably close to the

stream which provided water for use in preparation of food as well as for drinking and other domestic purposes.

Fall-plowed land which has been compacted and slightly eroded by rains and melting snow is the best type of ground on which to search for artifacts. Typical evidences which an experienced person may see on such sites are rough broken and darkened fire stones and broken chips and bits of flint. The better artifacts are usually found at the outer edge of the camp site or even a short distance further away.

Artifacts other than arrowheads and spearheads include axes, celts (both granite and flint), pitted stones, hammerstones, drills, scrapers, polishing stones, etc. One bear's tooth was found, identified by the authorities at the State Museum in Springfield. Bear's teeth were often worn as ornaments or charms.

As much pleasure may be gained around Indian camp sites in picking up kitchen middens such as large broken animal bones, broken pottery, discarded inferior arrowheads and spearheads, firestone, burned clay, charcoal, flint chips, flint percussion points, and flint cores, as in finding a perfect artifact.

Flint is a curious material, intensely hard, yet rather elastic. When it is struck by a hammerstone, the blow generally detaches a flake. The implements resolve themselves into two types. The first type is made from the core of flint itself, flakes being removed to give the desired shape. The larger implements like celts, axes, and hammers are shaped cores. The second type of implement such as knives, lances, arrowheads, spearheads, scrapers, etc., were fashioned flakes. In thinking how these different artifacts were made, we must remember the extraordinary patience of the Indians. One writer says that a North American Indian would spend all the leisure time of his life making one stone tomahawk. Try to make a flint implement yourself, but wear motor goggles to safeguard your eyes, and you will gain a new respect for these expert old handicraftsmen.

Evolution of Banner-stones

Byron W. Knoblock
LaGrange, Illinois

The skillfully carved relics of the mound building people show a remarkable workmanship and display an art and a simplicity of design surprisingly similar to the so-called "modern art" of today. Most of these relics can be definitely classified and their uses determined, yet there are problematical forms that can not be connected with any practical use. Banner-stones come under this heading. There is no doubt but that they were of vital importance to the Indians for their range of distribution indicates that they were very widely adopted tribal or ceremonial symbols.

I shall advance a few observations which lead me to believe that banner-stones had their origin in the southern states and which may help to prove that the southern states were the first area east of the Mississippi River to be occupied by the Indians. First may be cited the stone and copper relics, found in scattered sections of these southern states, that are typical of Mexican cultures and that were evidently carried into this area by migratory Indians from Mexico. Second is the fact that so many simple shaped banner-stones are found in Alabama, Georgia, and South Carolina. Or, to state it differently, in tracing banner-stones back through their "blending forms" to the simple forms from which they were developed, we are led back to this particular area.

It seems evident that the origin of all banner-stones began in the simple perforation of water-worn pebbles. Some of the early specimens show no attempt to alter the shape of the pebble, others show a slight amount of work but only to true up the shape. As the use of banner-stones became more popular, the Indians began to work the pebbles down into shapes that were more attractive, and from a few simple designs all banner-stones of the culture were developed.

As the southern tribes migrated in different directions they left a trail of scattered specimens in the territories that they occupied. These specimens not only establish a means of tracing their origin and evolution, but also establish, fairly well, the migratory routes of the Indians from the southern area.

Some writers have advanced the theory that the crescent shaped banner-stones so common throughout the New England states originated as effigies of the tail of the whale. As a matter of fact, crescent-shaped banner-stones of granite also occur in the lower Ohio and Mississippi

Valleys, too far from the seaboard for such an origin. To consider them as symbolic of the moon would be more reasonable. It is more logical to consider the crescent-shaped banner-stones from these two widely separated areas as having all been derived from the early crescent shapes which originated in Alabama, Georgia, and South Carolina. Their separate occurrence thus may well represent two northward migrations from a common center, one along the Atlantic coast and the other into the lower Mississippi Valley and hence gradually into the lower Ohio River valley.

I have come to the conclusion that the specimens of bannerstones showing the highest stage of development in design should be referred to as "types"; all other specimens that lead up to the "types" are referred to as "blending forms".

My entire theory of the evolution of types and the means whereby the varied shapes of banner-stones can be classified is based wholly on the similarity of lines and planes. On this basis there are but 24 distinct classes that developed 32 "types," which can be classified by certain characteristics. This number includes four new types that, as far as I know, have never been named or described in any book. Many other specimens may appear to be independent but are not and merely belong to some particular class in which they are but blending forms that establish the evolution of some type. Of course further research may uncover other authentic types which should be added to this list.

The highly specialized types of the 24 classes developed from approximately eight "primary" forms that, in turn, were developed from simple perforated pebbles. A dozen or more specimens can be arranged to form the blending series of many classes of banner-stones. For purposes of classification I have divided the blending series into three classes, called "A", "B", and "C" classes, or the A, B, C system. "A" class designates the simplest forms; "B" class designates the blending forms that show the evolution of types; and "C" class designates the type specimens.

From the constructional angle there are but two groups of banner-stones, the "bi-faced" and the "single-faced" groups. All bi-pennate, or winged, specimens belong to the "bi-faced" group. Their lines and planes are symmetrically balanced. The wings, extending from each side of the hole, are the same in outline, with both sides of the same construction, and double-faced or "bi-faced".

Single-faced banner-stones are those that are not symmetrical in lines or balance, but are constructed in such a manner that one side is of one shaped plane while the other side is entirely different. For example, consider the "hour-glass" banner-stone. The one side is a flattened plane and the other side is shaped to a sharp ridge, giving this side of the stone two planes. The flattened plane may be called

the "back". The ridged side, with the two planes, may be called the "face". The fact that these shapes have but one face places them in the "single-faced" group.

In my opinion, the so-called "saddle-back" types were wrongly named years ago. According to my method for naming the planes, the flat plane of these particular specimens is the "back", the ridged or "saddle" surface is the "face". On this basis they should be called not "saddle-back" but "saddle-faced" banner-stones.

The foregoing conclusions have been reached after exhaustive study of many large collections and are based on facts. The courteous and helpful cooperation of the museums, universities, and private collectors over the country has aided me materially by allowing me to study many specimens and hundreds of fine photographs.

The Teeth and Bones of the Mound Builders as Related to Their Diet

J. B. Ruyle, D.D.S.
Champaign, Illinois

ABSTRACT

For the past two years, through the courtesy of Curator Frank C. Baker, of the University of Illinois Natural History Museum, the writer has had the privilege of examining and studying the skeletal material reposing in the Archeological Laboratory—material collected in central and southern Illinois over a period of several years, by Drs. A. R. Kelly and Warren K. Moorehead, formerly of the University. The study of this material was supplemented by similar work done on material available at the Dickson Mounds near Lewistown, and at the Field Museum in Chicago. The writer was also granted access to several excellent private collections in various parts of the State. The entire project involved the observation and measurement of hundreds of skulls and thousands of teeth.

Throughout the course of the investigation two noteworthy observations remained predominant. Evidence of dental caries, or decay of the teeth, was practically non-existent and was almost totally confined to teeth of aged individuals. This latter fact is established by the fact that such jaws had lost teeth before burial, the remaining teeth were tipped or spaced, or both, thus creating pockets wherein food material was easily retained. Subsequent fermentation caused the formation of organic acids that tended to soften the enamel rods, allowing the ingress of destructive mouth fluids. In spite of the fact that caries seemed to be a characteristic of the skulls of the elder individuals, they made up a total of only seven per cent of the skulls studied. In addition to the fact of comparative freedom from caries, the skulls showed remarkably fine development of the alveolar arches. The arches exhibited almost ideal proportions of length, breadth and height. The mandible was correspondingly well developed.

The problem of satisfactorily explaining this immunity from caries, and the marvelous development of the osseous structures of the mouth, was attacked from the standpoint of the influence of diet on such conditions.

Extensive excavation of village sites, camp sites, kitchen middens, refuse mounds, etc., carried on in recent years, has given us a wealth of

knowledge regarding what must have comprised the bulk of the diet of the aboriginals of Illinois. A noteworthy example of this type of study is the careful work done by the members of the Peoria Academy of Science, in excavating the Kingston Pits. The material collected at this site was forwarded to the University of Illinois and to the Smithsonian Institution for examination and classification. At the 1930 meeting of the Academy Dr. Baker presented the results of his work on it, revealing that the Mound Builders ate certain specific types of mollusca, fish, birds and mammals. He identified, among other things, the bones of the Sand Hill crane, the trumpeter swan, the whooping crane, the Virginia deer, black bear, and beaver; now, for the most part, extinct in the Illinois Valley region. The dog was evidently eaten to some extent, as well. A large percentage of the bones were found to have been cracked open, showing that the bone marrow was eaten after the meat was consumed.

The Mound Builders also practised agriculture in a crude sort of fashion. The early French explorers, during their voyages along the streams of Illinois, noted fields of corn adjacent to the Indian villages. Pumpkins were also grown. In their planting procedure they poked a sharpened stick into the soil, dropped the seed into the hole thus formed, and then covered it up, leaving it to germinate and produce crops without further human aid. When the game supply became depleted in any one area, the tribe would move to another locality. Thus their agricultural efforts were always carried on in virgin soil. Recent studies have shown conclusively that agricultural products derived from virgin soil possess a much higher mineral content than those secured from soil that has been utilized for a number of years. This fact is important in the study of dietary results.

Vegetable foods prepared from corn and pumpkins were supplemented in season by wild strawberries, gooseberries, blackberries, wild plums, wild onions, and undoubtedly, other tree and plant produce as well. The Mound Builders prepared their cooked foods by only brief exposure to fires of low temperature; hence the victuals retained most of the natural mineral and vitamin content. This fact is also important. Furthermore, the common method of cooking resulted in the addition of more mineral matter derived from the abrasion and decomposition of the heated stones used to supply the necessary heat, and from the unfiltered water which was used. Gritty materials were introduced into their cornmeal, also, as the stone grinding implements wore down during use.

Taken as a whole, then, the diet of the Mound Builders was exceedingly rich in the minerals and vitamins necessary for the proper growth and development of the teeth and bones. Compared with the average diet of the modern American it was more than five times richer in calcium and phosphorous compounds, and more than fifteen times richer in copper, magnesium and iodine-containing substances.

The above facts seem to supply an adequate explanation for the well-developed teeth and oral bones that characterize the skulls of the Mound Builders, taking for granted the fact that the skulls examined in the current study were typical of the race. Not only were their foods rich in important basic substances, but the introduction of gritty materials tended to remove scale from the teeth, and to scour out the fissures of the occlusal surfaces, thus preventing the retention of food at such spots. It is true that such involuntary tooth-cleaning was more effective than necessary, thus resulting in extreme wear of the teeth with age. The proximal surfaces of the teeth in time became squared off, inducing packing and subsequent decay of the teeth of the older members of the tribes.

The dentition of the Mound Builders was markedly superior to that of the present day civilized person. The differences in dietary practices undoubtedly accounts for the contrast. The average forty-year-old individual of today, if he does not have "false teeth", has, or should have, in most cases, more or less bridgework. Otherwise, his mouth exhibits typically numerous fillings and crowns. His alveolar arch is typically high, short, and narrow—imperfectly developed. His teeth are usually crowded; the third molars are commonly impacted, and his teeth more often than not show incipient or active pyorrhea. Our modern diets, rich in carbohydrates and starches, are generally poor in mineral and vitamin content. They do supply food for the flesh of our bodies, but they should also supply food for thought and corrective action.

Archaeological Survey of Peoria County

A. M. Simpson

Peoria Academy of Science, Peoria, Illinois

One objective of the Ethnology Section of the Peoria Academy of Science, the past season, was the mapping of prehistoric habitation sites in Peoria County. Sixteen sites and 24 mounds have been located, photographed, and artifacts on each site tabulated. The location of the sites and the camp refuse found on the surface and subsurface give evidence of two basic cultures in this county.

The *Woodland* people, so far as surface material indicates, chose their village sites on high bluffs that approach the river, on narrows between, and on bluffs of spring-fed streams of the Illinois River.

A Woodland culture site is located on a narrow terrace between the Illinois River and the bluff on the Gauwitz farm. It is about five acres in extent and shows some signs, on the subsurface level, of a different culture below. Much camp refuse consisting of flint chips, large celts, stemmed points, burned rock, chert blades and grit-tempered sherds which show rouletting, stamping and cord markings, were found. A cache of 100 flint blades was found here. All other bluff sites produced about the same surface finds except one, in which there were many small triangular points of the Mississippian type.

From the bluffs to the Illinois River bottoms, the scene changes. Here we find the *Mississippi* culture predominates in four sites along the thirty miles of river front. The *Kingston* site, the most extensive, covers about ten acres. It has included four mounds which have been destroyed. The artifacts found on this site were taken mostly from the sub-floor and storage pits. Fire pits produced but few. Storage pits were from 5 to 6 feet deep and half as wide. Over 3,000 specimens were collected from them, representing 45 varieties of artifacts. The pits contained, besides the camp refuse, layers of black earth, gravel, ash and shell. The shell was intentionally placed in many pits. As to other fillings, whether placed for seasonal reasons, for sanitary purpose or to be from high water, has not been determined.

DESCRIPTION OF A FEW FINDS

Awls made mostly from deer bones. A few made from the bones of turkey, bird, dog and fish. One fashioned from the lower jaw of a long nosed gar. In most cases the bones were split, one end sharpened and the shaft left in the rough. Many were made from the calcaneous bone of the deer.

Paint Stones made of sandstone, circular in form, from 5 to 8 inches in diameter and from ½ to 1 inch in thickness. Only one face was used for grinding of paint.

Bone Fish Hook from 1⅜ to 2 inches in length, shaft rounded with a knob or groove cut near the end of the shaft. None were barbed. All were made from deer bones.

Game Bones fashioned from the small bones of deer feet. The larger joint was cut off and the smaller was perforated either by drilling or by making a diagonal cut through the joint.

Clay Disks made from potsherds and shale. Some were perforated, many were left blank.

The contents of one pit, two feet deep and fourteen inches in diameter, included the shells of nine large river clams, resting on a hard clay floor and covered with four inches of clay burnt to a brick red. Black dirt long since had taken the place of the clams. No doubt a forgotten "clam bake" of decades ago.

ARTIFACTS TAKEN FROM PITS AT THE KINGSTON VILLAGE SITE

Small triangular projectiles
Knives
Celts
Pitted stones
Sandstone sharpeners
Discoidals
Anchors
Sinkers
Anvils
Paint stones
Scrapers
Slate disks
Hammerstones
Stone pipes
Stone balls
Shell spoons
Shell hoes
Shell ornaments
Shell beads
Ear ornaments
Clay disks
Clay bowls
Shell-tempered clay (not fired)
Woven fabric
Corn carbonized
Nuts
Paw Paw seed
Squash seed
Mushroom clay trowel
Cooper beads
Bone awls
Bone needles
Bone fish hooks
Bone ornaments
Beamers
Bone beads
Bone arrow points
Game bones
Deer jaw hoes
Bone chippers
Beaver-tooth chippers
Bone plaques (turtle plastron)
Elkhorn chisels
Skull trophies
Bone of mammals, birds, fish, and shell

And several undetermined objects

CONCLUSIONS

(1) Site location in one determinant of culture.
(2) No indication of European contact.
(3) No storage pits were found in *Woodland* culture sites.
(4) Mississippi sites produced a majority of bone and shell tools while Woodland produced a majority of stone tools.
(5) It was not determined whether storage pits were inside or outside of huts.
(6) The plant *Gonolobus laevis* (Angle Pod) was found growing on Indian sites but has not been located elsewhere in the county. (Noted by Virginia Chase, Peoria.)

An Interesting Anthropological Find From the Lake Michigan Region

W. C. Van Male

Waukegan, Illinois

The antiquity of man in America always has been a topic for much discussion. Until recently it has been supposed that man was a comparatively late arrival upon this continent. This belief has been much altered by several discoveries of human remains and man-made tools in association with the skeletons of Pleistocene mammals. The most notable of these was made at Folsom, New Mexico.

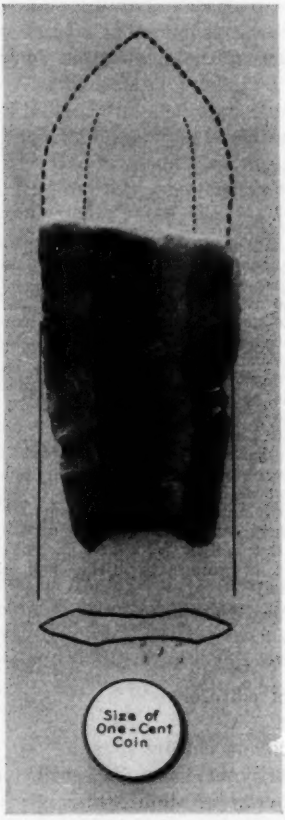

Fig. 1.—Point of "Folsom" Type Found in Lake County, Illinois.

The discovery at Folsom gave conclusive evidence that the region was inhabited by man at the close of the great ice age. At a depth of four to thirteen feet, spear or javelin points were found among skeletons of an extinct species of bison. After a careful study of these remains, Dr. Barnum Brown, Curator of Fossil Reptiles of the American Museum of Natural History, placed them at the close of the Pleistocene period. It is highly probable that these Late Pleistocene mammals were hunted and killed by the men who used the points on their weapons.

Typologically, these points are very much unlike the characteristic surface finds, left by the later American aborigines. The typical "Folsom point" is too large to have been used on an arrow, but instead was affixed to a small spear or javelin. It is thought by some authorities that these javelins were hurled with considerable force by means of the throwing stick. The point itself tapers towards its concave base, the widest part being nearest the anterior end. There is a smooth longitudinal groove, formed by the removal of a single long flake, on each side. The materials used for this weapon are jasper or chalcedony.

Several years ago an artifact that had all the Folsom characteristics, was found by the author in Sec. 11, Libertyville Township, Lake County, Illinois. It is made of chalcedony and is an almost exact facsimile of those found at Folsom, N. M. The pointed end is missing, but the largest part of the piece is still intact. It was excavated by a ditch digging machine; so unfortunately, the exact depth of the find could not be determined. The field in which it was found is of yellow-gray silt loam and had been under cultivation for years. Several arrow points and other artifacts of the Middle Mississippian culture had been found on the surface here, but there was nothing else that could have been associated with the "Folsom type".

This find may be of little consequence, but is, nevertheless, worthy of mention. The fact that there were no other remains in association with it, and that it was not found *in situ,* decreases its scientific value. However if typology were given the significance it has in Europe, there would be little doubt that some connection exists between the Lake County point and those found at Folsom. It would, therefore, be a reasonable conjecture that Northern Illinois had human inhabitants in Late Pleistocene times. On the other hand, the finding of a point identical to the late ice age points of Folsom may be merely a coincidence.

The Evolution of the Mouth

L. H. Wolfe, D.D.S.
Quincy, Illinois

The teeth show an adaptive modification of structures to change in bodily functions and have been modified during the various stages in development from the lowest organisms to the highest forms. Osmosis is the process of alimentation of the ameba. There is no special collection of cells at the orifice of the alimentary canal of the *coelenterata,* or the annuloida for the preparation of food. In the arthropoda and crustaceans, there are cells at the beginning of the canal which partially prepare the food. In the suctorial mouth of the *Petromyzon marinus* there are corneal modifications of the epidermis which serve as teeth. Their attachment to the maxillae and mandible are acrodont, pleurodont and thecodont. In the rays there is a sexual difference in the shape of the teeth. The authority for the above statement is Hopwell-Smith, and as this paper is being prepared, the writer is planning to verify this statement with research in this particular field. Some amphibians have no teeth, as the *Bufo americanus,* while others, as the *Rana castesbiana,* have teeth not unlike the pisces, at least always on the maxillae but the mandible of the *Rana castesbiana* is edentulous. Most reptilia have teeth and the mandible is jointed at the symphysis and articulates with the skull through the quadrate bone. The poison fangs of the crotalus, etc., are in the maxilla and in the *Heloderma suspectum* the venum conducting fangs are in the mandible. The chelonidae have a horn-like covering for the border of the jaw. The aves have no teeth, the beak being a horny sheathing of the ends of jaw bones and some with serrations. The first type of tooth of interest other than a fang is the molar of the ungulates which are herbivorous and granivorous. The molar teeth of the *Equus caballus* are good examples of teeth in a jaw with a marked lateral excursion of the mandible. This is practically the only motion of the mandible and makes the serrations of the molars run antero-posteriorly; which is exactly the reverse of the form of molars of the rodentia, in which a postero-anterior movement of the mandible is responsible for the grinding necessitating a different arrangement of the occlusal surface of the teeth. In the rodentia, we find the persistent pulp and the tooth grows out as it is worn off. The carnivorous animals differ from the class just described in the character of their teeth and also in the manner of the movement of the mandible. The skulls of a *Procyon lotor* and *Odocoileus hemionus* show a vast difference in the grinding teeth as shown in their mandibles. The carnivorous molars comminute while the herbivorous molars triturate. There is a marked difference in the tempormandibular articulation of

these two animals. The herbivorous have a flat glenoid fossae to render possible the lateral excursion of the mandible. The carnivorous animals have no lateral excursion. The condyles fit into the fossae so tightly as to make a hinge joint, and in some instances the distal part of the eminentia articularis so far over hangs its glenoid fossa that it cannot be seen. In some cases it is necessary to fracture the skull to remove the condyles.

In the apes, dentures are found which are approximately like the human. In the new world monkey almost exactly the same type of denture is found as that of man, except that there are three bicuspids instead of two. There are two incisors, a cuspid, three bicuspids and three molars on each side. The old world monkey is the first animal representing exactly the dental formula of man. There is, however, a space between the upper lateral incisor and cuspid which is to admit the lower cuspid. These animals are largely frugivorous.

The human oral cavity has in front a transverse aperture, the rima oris; behind, it communicates with the pharynx through the isthmus faucium. An outer, the vestibulum oris, bounded externally by the lips and cheeks, and internally by the teeth and gums which cover the outer aspect of the alveolar process of the jaws. The maxillary arch is elliptical, the mandible is parabolic in outline. The teeth of man do not, normally occlude by means of their cusps, but by a perfect system of interdigitation. This is enharmosis.

In primitive man the upper incisors came into opposition edge to edge with the lower incisors, and were frequently worn flat in consequence. While in modern man there is a tendency for them to over bite. The third molars are the last to erupt and among the first to be lost and some never erupt. In prehistoric man they erupted and functioned in mastication. A fourth molar may be observed occasionally in the gorilla and much more frequently in the orang in which a fifth tooth has been noted in rare instances. Accessory molars are very infrequent in the gibbon and in the old world monkeys. This anomaly is found occasionally in American monkeys ateleus. In modern man we find supernummerary incisors and molars, and the jaws are generally short and not as prognathous, and the teeth are inclined to be irregular and crowded.

Owing to the effects of civilization, the teeth of the high classes of both the American and European people are often carious, which is not so much the effect of a weakness of structure of the teeth as it is the result of unnatural foods and habits.

Wiedersheim reports upon evidence of caries of the teeth, after an examination of a large number of skulls from various museums as follows: Esquimaux 2.5 per cent; Indians 3.10 per cent; Malays 3.20 per cent; Chinese .40 per cent; Europeans 80-100 per cent.

For several generations man has been endeavoring to trace a resemblance between human beings and apes. The earliest trace of fossil man

yet discovered in Europe is that of the jaw of *Homo heidelbergensis.* The main features were the massive character of the long frame work, which at first sight seemed more anthropoid than human, that the masticatory muscles must have been more highly developed here than in any known human race. The jaw is believed to have been 1,000,000 years old. The Neanderthal skull (*Homo mousteroemsos*) was unearthed near Dusseldorf in 1856, a few years before the publication of Darwin's "Origin of Species". This skull had an extremely flattened cranium with largely developed superciliary ridges. In 1910, on the south coast of Jersey after the removal of 25 feet of material nine teeth were discovered, which without doubt belonged to an individual of the Neanderthal race, but in certain features are more primitive than the teeth of the Heidelberg mandible. In 1886, two skulls were found at Spy in which the third molars were larger than the second and these than the first, all having three roots. It is probable that the Heidelberg and Neanderthal are survivals of a very ancient type and in no way indicative of the stage reached by *Homo sapiens.* In 1891, a skull was brought to Europe from Java *(Pithecanthropus)* which appeared to be intermediary between man and ape. The skull of a Pre-Boulder clay man was discovered which is thought to be 100,000 years old or more. The jaws were lost, but the isolated teeth were preserved and found to be small in size, very much worn down, not materially different from the modern type of tooth, and totally dissimilar to those of Neanderthal man. The next oldest, as far as yet ascertained, is the skull found in excavating for the Tilbury Docks in 1883, which is probably 30,000 years old. The Indians of America are generally macrodonts, the teeth being large, strong and well set in a round arch. There is a considerable variety among the divers races of North and South America, large, medium and small teeth are found. Deformities are not infrequent and fourth molars and third incisors sometimes occur. The mound-builders had fine teeth in a round arch, and were yellow. The ancient Aztecs had small arches and small fine teeth. The Indians of the United States of later times had large fine teeth, but with the degeneracy and disease incident to the vices acquired from the white man, they became degenerate and defective.

In conclusion, as animal life progressed from the higher forms of invertebrates to the lower forms of vertebrates, a specialization of the digestive tract evolved bringing with it the inauguration of special organs for mastication. As higher forms of vertebrates evolved, so the dentition became more efficient to take care of the needs of the digestive tract and food habits of the animal. So we see that dentition may differ considerably from species to species and different genera within a single family show how completely dissimilar one dentition may be from another.

DEWEY-THOMPSON, "Comparative Dental Anatomy."
TODD, "Mammalian Dentition."
HOPEWELL-SMITH, "Dental Anatomy and Physiology."

PAPERS IN BOTANY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

Of the eleven papers on the program of the Botany Section meeting, the following three are not here represented:

Response of Some Sensitive Stigmas, by Harry J. Fuller, University of Illinois, Urbana.

A Demonstration (microprojection) of the Lily-type Embryosac as Redescribed by D. C. Cooper, by E. L. Stover, Eastern Illinois State Teachers College, Charleston.

The Unit of Instruction in General Botany, by Jerome Isenbarger, Wright Junior City College, Chicago.

About fifty-eight persons attended the meeting.

Dr. Neil E. Stevens, Department of Botany, University of Illinois, Urbana, was elected chairman of the section for the 1937 meeting.

(Signed) HARRY V. GIVENS, *Chairman*

Influence of Certain Organic Substances Upon the Growth Behavior of Excised Root Tips

Gladys C. Galligar

James Millikin University, Decatur, Illinois

INTRODUCTION

The idea that certain organic substances may exercise an influence upon the amount and type of plant growth has been a controversial question for many years. Some work of this nature has been done with excised root tips as the subject. Kotte found that root tips were affected beneficially by the addition of meat extract to Knopf's solution. Robbins found beneficial effects from the addition of peptone and autolyzed yeast to a modified Pfeffer's solution. Other organic substances used by both men had no beneficial effect. In this study legumin-trypagar, brain heart infusion, yeast-dextrose agar, and different concentrations of dextrose and peptone were tried on different species of excised root tips with varying degrees of positive results.

MATERIALS AND GENERAL METHODS

The procedure to secure sterile root tips involved several steps and in the main followed that of Robbins (2). The seeds were soaked for 4 hours in a solution of Zonite diluted 1-30. They were then transferred by means of steel forceps to Petri dishes containing a thin layer of 0.75 per cent sterile agar agar, where they were allowed to germinate. The ends of the forceps were passed through a Bunsen flame and cooled in sterile water each time before touching the seeds. When the roots had grown approximately one inch, the tips were cut off in uniform lengths of 1 cm. by a steel scalpel, which was flamed and cooled before each operation. The excised root fragments were transferred by means of a sterilized wire loop to Pyrex Erlenmeyer flasks of 125 ml. capacity carrying 50 ml. of sterile nutrient media. The inoculated flasks were kept in a laboratory with curtains drawn, where they received very weak diffuse light and where the temperature varied no more than 3° F. (68-71° F.) during the experiment.

The nutrient solution was a modification of Pfeffer's formula to which was added dextrose and peptone.* Immediately after being made, the solution was measured into the flasks, which were closed with cotton plugs and autoclaved at 15 pounds pressure for 20 minutes.

* $Ca(No_3)_2$	2.0 gm	KCl	0.25 gm.	Dextrose 2.0%
KH_2PO_4	0.5 gm	$MgSO_4$	0.5 gm.	Peptone .04%
KNO_3	0.5 gm	$FeCl_3$	0.005 gm.	Distilled H_2O 6000 C.C.

TABLE I.—A SUMMARY OF DATA ON 100 ROOT TIPS OF CORN CUT AT ORIGINAL LENGTHS OF TEN MILLIMETERS AND GROWN IN THE MODIFIED PFEFFER'S SOLUTION WITH VARYING CONCENTRATION OF PEPTONE

Peptone per cent	Average daily increment in mm. of length of 10 root tips for 1st 10 days										Average total length in mm. at end of 28 days	Range in lengths in mm. of individuals	Average number lateral roots	Range in number of lateral roots among individuals	Average dry weight in gms. per 10 roots
	1	2	3	4	5	6	7	8	9	10					
0.04	4.6	3.4	3.4	0.2	5.6	2.6	2.3	3.6	6.6	2.5	145	95–290	89	34–103	.223
0.1	1.2	2.6	3.0	2.0	4.8	1.4	2.4	2.5	1.3	1.6	115	55–210	59	24–103	.212
0.2	2.0	1.0	1.5	1.3	2.2	1.4	1.8	0.2	2.8	1.2	62	38–160	9	0–27	.200
0.3	1.6	0.6	1.5	1.6	1.7	1.8	1.6	2.4	1.6	1.2	54	31–70	5	0–21	.215
0.4	1.4	1.6	1.0	0.8	0.7	1.0	1.2	1.5	1.0	1.0	44	30–65	4	0–13	.180

Daily increments in length were measured by placing a mm. rule under the flasks. Final data on dry weight, total length and number of laterals were tabulated and summarized for reference.

Deviations from the general method are stated in the discussion of results for each separate treatment.

DISCUSSION OF RESULTS

(1) Influence of increasing the amount of peptone in the nutrient solution upon the character of growth of root tips of dent corn.

In a preliminary experiment a mistake was made by the addition of too much peptone to a quantity of the basic solution. This solution was used as made up to determine its influence upon the growth behavior of excised root tips of corn. Their growth differed so markedly from that of the same kind of root tips grown with the normal amount of peptone in the basic solution that a series of experiments was performed to determine what concentration of peptone initiated the effect. The root tips became quite thickened in diameter, grew less in length and produced fewer branches, which were also quite thickened.

The basic solution was made up with five concentrations of peptone as follows: 0.04 per cent as in the normal solution, 0.1 per cent, 0.2 per cent, 0.3 per cent, and 0.4 per cent. Root tips of corn were allowed to grow in these solutions for four weeks.

Figure 1 shows clearly a noticeable change in growth habit as soon as the concentration of peptone was increased to 0.2 per cent. There was a preponderance of shorter and thicker roots with fewer laterals. This tendency became more marked as the concentration was increased to 0.4 per cent of peptone, where all the roots were short and thick with very few to no laterals at all.

Table I, however, shows no noticeable difference in average dry weight until the concentration of peptone reached 0.4 per cent. There was a distinct inhibition of elongation within the first ten days, when the concentration reached 0.2 per cent.

It might be said that the effect is due to increased osmotic concentration of the solution. To test this possible factor, the osmotic concentration of the basic solution was increased by adding more dextrose and maintaining the normal concentration of peptone. The phenomena of osmosis is dependent upon numbers of particles in solution and not upon weight. The empirical formula of dextrose is known, while that of peptone is not known definitely. Peptone, whatever its empirical formula may be, is composed of molecules which are much larger than those of dextrose. It follows that a given weight of peptone

TABLE II.—A SUMMARY OF THE DATA ON 50 ROOT TIPS OF CORN CUT AT ORIGINAL LENGTHS OF 10 MILLIMETERS AND GROWN IN THE MODIFIED PFEFFER'S SOLUTION WITH VARYING CONCENTRATIONS OF DEXTROSE

Dextrose per cent.	Average daily increment in mm. of length of 10 root tips for 1st 10 days										Average total length in mm. at end of 28 days	Range in lengths in mm. of individuals	Average number lateral roots	Range in number of lateral roots among individuals	Average dry weight in gms. per 10 roots
	1	2	3	4	5	6	7	8	9	10					
2	2.6	4.5	4.7	3.2	2.0	3.2	2.3	6.0	2.0	6.5	138	54–234	94	0–118	.213
2.5	3.0	2.0	4.5	1.4	3.3	2.3	3.7	4.2	4.3	3.0	141	41–251	87	10–121	.208
3	3.2	4.0	2.3	4.7	5.9	2.5	3.5	2.1	1.0	4.0	136	45–268	97	0–128	.224
3.5	3.70	2.15	4.92	3.02	5.01	4.00	5.35	3.77	5.89	4.27	129	38–189	72	3–97	.170
4.0	2.71	3.20	3.23	2.94	1.20	2.74	3.93	1.33	2.63	2.91	78	32–91	20	0–54	.185

would have a smaller number of osmotically active particles than the same weight of dextrose. Neither substance ionizes in solution. The concentrations of glucose used, namely, 2 per cent, 2.5 per cent, 3 per cent, 3.5 per cent and 4 per cent, produced an increase of osmotically active particles per unit volume far beyond the range produced by the increased concentrations of peptone.

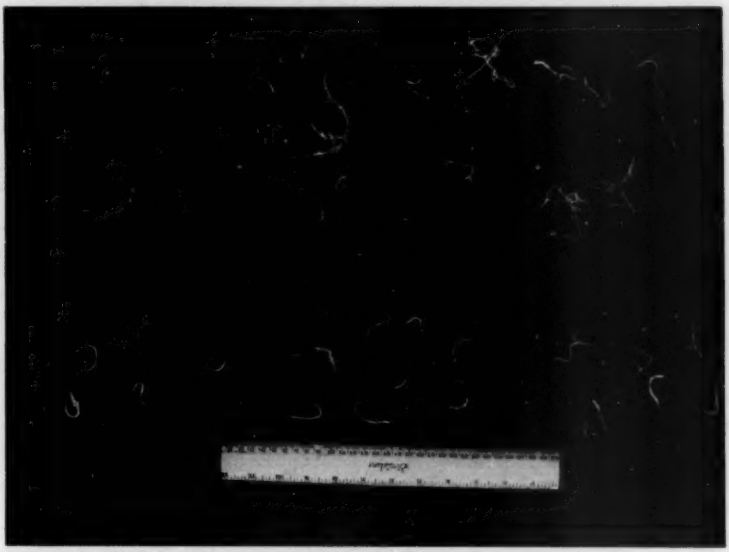

Fig. 1.—Groups of corn roots, which have been grown in the basic solution with varying concentration of peptone. Upper left: normal concentration of peptone (0.04 per cent). Upper right: 0.1 per cent peptone. Lower left: 0.2 per cent peptone. Lower center: 0.3 per cent peptone. Lower right: 0.4 per cent peptone.

Figure 2 shows that there was no particularly great difference in character of growth until a concentration of 4 per cent dextrose was reached. There was the usual wide variation in each group of roots; thickened roots with few or no laterals occurred throughout the series, and not until a concentration of 4 per cent dextrose was reached was there a marked reduction in average total length, in average number of lateral roots, and in average dry weight (Table II.) This is hardly in accord with Robbins' (3) findings that corn root tips grew to greater lengths and produced more laterals in the dark in twenty-four days in 4 per cent dextrose than in 0.2, 0.5, 1, 2, or 6 per cent dextrose. However, a comparison of results cannot be made directly with those of Robbins, because Robbins used a modified Pfeffer's solution six times

TABLE III.—SUMMARY OF DATA ON 35 ROOT TIPS OF CORN GROWN IN THE MODIFIED PFEFFER'S SOLUTION WITH 2 PER CENT DEXTROSE, 0.04 PER CENT PEPTONE, AND 0.1 PER CENT LEGUMIN TRYPAGAR

Species	Average daily increase in mm. of length of 30 root tips for first 10 days										Average total length in mm. at end of 10 days	Average final total length in mm.	Range in final lengths in mm. among individuals	Final average number lateral roots	Range in final number of lateral roots among individuals	Average dry weight in gms. per 10 roots
	1	2	3	4	5	6	7	8	9	10						
Corn	3.65	2.93	2.04	3.86	4.75	5.23	3.05	2.17	2.00	3.25	32.93	179.3	55–210	221	78–330	.312

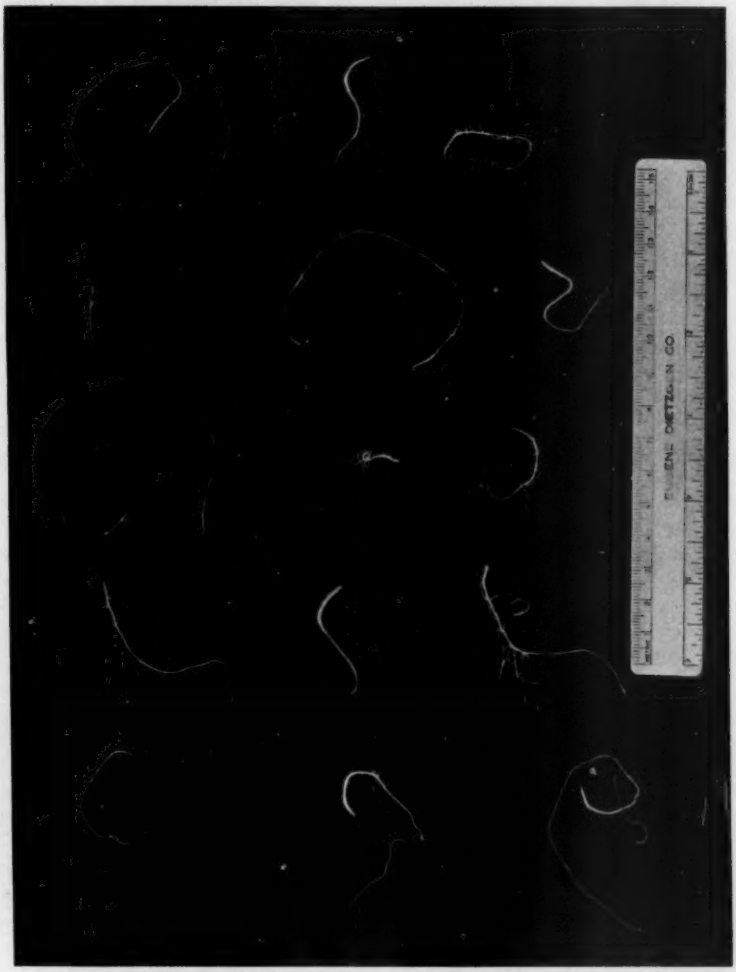

Fig. 2.—Representative root tips of corn grown 28 days in Pfeffer's solution and peptone with different concentrations of glucose. Top row, 2 per cent glucose; second row, 2.5 per cent glucose; third row, 3 per cent glucose; fourth row 3.5 per cent glucose; fifth row, 4 per cent glucose.

the original strength and added no peptone. The presence of peptone used in the present experiments and the weaker concentration of salts might have had a combined effect to alter the behavior of root tips grown in such a solution, to which increasing amounts of dextrose were added.

(2) Influence of legumin-trypagar, brain-heart infusion, and yeast-dextrose agar upon the growth of excised root tips of dent corn, pea and cotton.

To the basic solution was added as much of the yeast-dextrose agar as would keep the concentration of peptone in the final solution at 0.04 per cent, in order to avoid the influence of additional amounts of peptone, which would have seriously complicated the results, as has already been pointed out earlier in this paper. In the second series of experiments brain-heart infusion was added to the basic solution with the same precaution. In the third series of experiments 0.1 per cent of legumin-trypagar was added to the basic solution. In the latter case no peptone was present in the compound added; therefore, no calculations were necessary to keep within bounds in regard to peptone, since it was added separately in the normal amount. The three compounds were obtained from the Digestive Ferments Company, Detroit, Michigan.

Thirty ten-millimeter root tips, in three series of ten individuals each of cotton, corn, and pea were grown for eight weeks in each of the three solutions. Daily observations of increment in length were made for a period of about two weeks. At the end of the experiments the usual final data were recorded.

Since no difference in behavior were secured from the use of brain-heart infusion and of yeast-dextrose agar in the three species of root tips used the results are not reported here in tabular form. They were too nearly like those obtained in the first experiments reported in this paper with the use of the basic solution alone to warrant space for recording.

However, the legumin-trypagar acted as a marked stimulant to the growth of corn root tips and in a few isolated cases to the growth of pea root tips, but no effect was noticeable in cotton.

Figure 3 shows one corn root, which was obtained entire and which shows very well the uniformly thickened root with its well-developed laterals thickened in the same manner. This one root was typical of about sixty-five per cent of the root tips that were grown in the legumin trypagar. There was in every case a comparatively short root with an abundance of long and very well developed laterals. The entire root system was quite uniformly thickened. This robust appearance was never observed in well developed roots of corn grown in the original basic solution. In the latter case the roots were more slender and the

laterals were usually smaller in diameter than the main axis of the root. One individual corn root tip grew to astounding proportions, attaining a dry weight of 0.254 grams with a length of 143 millimeters, having 332 laterals and subbranches ranging from 9 to 97 millimeters, making a grand total of approximately 9920 millimeters of root, representing an increase of 992 times the length of the original fragment. This root could not be photographed because in washing it out for examination it broke apart due to the bad entanglement within a 125 millimeter flask.

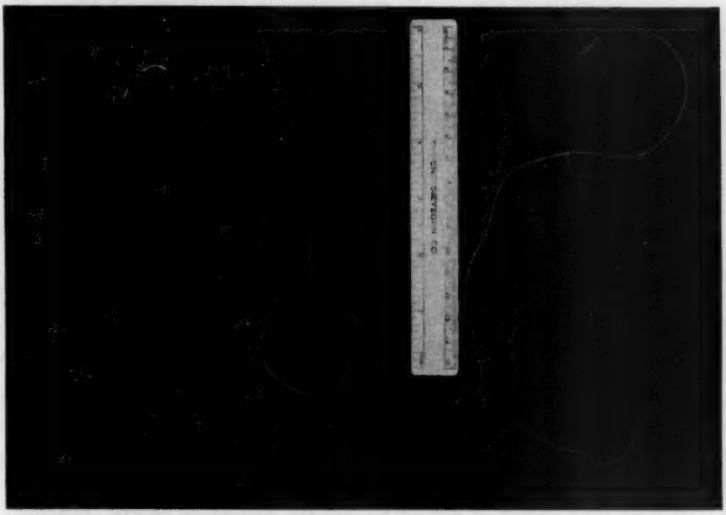

Fig. 3.—Upper left, pea root grown in legumin trypagar; left, corn root grown in legumin trypagar; right, corn root grown in dextrose solution.

The root tips of pea, which seldom developed lateral roots under any circumstances and then only very short stubby ones of one or two millimeters length, grew to greater length about forty per cent of the time and produced from one to five laterals, ranging from three to twenty-nine millimeters (Fig. 3).

Although no differences in general behavior were noted in cotton, three of the roots deviated far from their ordinary habits. In these three roots the epidermis split longitudinally in one place and through this slit there emerged small outgrowths of the parenchymal tissue of the cortex, which reached the size of a cabbage seed. The cells were very large and loosely arranged as in certain peculiar proliferations secured in a few cases from one-millimeter tips of sunflower. These outgrowths were easily discerned because of their contrasting tan color to the black epidermis.

(3) The effect of dextrose and distilled water on the growth of root tips of dent corn.

In this experiment ten root tips each ten millimeters in length were grown eight weeks in a 2 per cent solution of dextrose to determine their behavior in the absence of mineral salts. These roots exhibited the same uniformly thickened appearance as that caused by legumin trypagar, but there were few laterals (Fig. 3). In several cases there was liberal pigmentation due to anthocyanin, although anthocyanin never developed in root tips of corn grown in the original basic solution. The root pictured in Fig. 2 was the longest in the series. None of the others in the series were half as long.

SUMMARY

(1) Peptone in concentrations of 0.2 per cent or more inhibited the growth and formation of laterals in root tips of corn.

(2) A concentration of 4 per cent of dextrose was reached before noticeable changes were observable in corn root tips.

(3) No noticeable harmful or beneficial effects were secured from brain-heart infusion nor from yeast-dextrose agar on the growth of root tips of dent corn, pea, and cotton.

(4) Legumin-trypagar acted as a stimulus to the growth of excised root tips of dent corn and pea, but had no effect on cotton. The stimulus caused an increased development of lateral roots.

(5) Corn root tips grown in the presence of 2 per cent dextrose without mineral salts developed into short thick roots with few laterals.

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Sample-Plot Statistics in University Woods

W. M. Marberry, J. D. Mees and A. G. Vestal
University of Illinois, Urbana, Illinois

Data for this study of the University Woods east-northeast of Urbana were obtained in 1935 by M. E. Barnes, Everett Green, Dawn Neil, and the authors. Tabulations from 42 scattered circular plots of one-eighth acre size studied by John Hanley in 1931 were also available. The 1935 plots comprise 64 tenth-acre squares arranged in a grid (528 feet square), south of the middle of the 60-acre forest. Of the 30 tree species observed in this mixed mesic forest, 24 are represented in the plots. Abundance data were plotted separately for trees of the different species for 36 of Hanley's circles, for the 64 contiguous squares, and for a composite sample totaling 10 acres. For the latter we find the leading species represented as follows: Hard maple, 36.5 trees per acre; American elm 15.7, white ash 15.5, red elm 11.9, linden 9.4, buckeye 7.0, hackberry 5.3, papaw 3.7, northern red oak 3.5, walnut 3.3, blue ash 2.9. Yellow oak, Q. Muhlenbergii (No. 16 in order of abundance, but with larger trees than most other species) 1.3 per acre; bur oak (No. 17, also large trees) 1.0; trees of all species, 125.6 per acre.

The relation between size of plot and number of species represented in a plot was studied by arranging neighboring squares of the grid into groups of graduated sizes, 0.1 to 1.6 acres, according to patterns giving as nearly regular shape and arrangement of groups of squares as was permitted. Thus the 64 squares were arranged successively into 32 2's, 21 3's, 16 4's, 12 5's, etc., up to 4 16's. Other rearrangements gave somewhat less dependable data for plots aggregating 24, 32, and 48 squares. From the mean numbers of species for the successive sizes of the aggregates, a species-area curve was constructed. Mean species numbers for different-sized plots:

0.1 acre	5.4 spp.	0.7 acre	13.5 spp.	1.4 acre	15.8 spp.
0.2	8.1	0.8	14.0	1.6	16.3
0.3	9.8	0.9	14.0	2.4	17.6
0.4	11.1	1.0	14.8	3.2	18.8
0.5	11.3	1.1	15.0	4.8	19.8
0.6	12.3	1.2	15.6	6.4	21.0

In this species-area curve, which is logarithmic in form, the change of direction is greatest at about 0.8 acre. An 0.8-acre plot, 8 per cent of the 10-acre sample, contains 14 of the 24 species of that sample, or 58 per cent. It is evident that further additions of species require

larger increases in sizes of plots; 0.8 acre is taken to be the ***minimal area*** (for trees) in mature mixed mesic forest in east-central Illinois. This minimal area is the smallest practicable unit which by itself may be taken as representative of its community.

The influence of shape of plot upon constancy of numbers of individual trees and species in a plot was studied by comparing four groupings of 0.8-acre plots within the 6.4-acre grid, as shown in the following table:

No. and Shape of Units	Trees per unit	Species per unit	Variance: S.D. as %
5 Circles	67–122	13.6	5.9
8 Compact plots	70–118	14.0	7.2
8 N-S strips	72–103	14.13	8.2
8 E-W strips	63–111	14.13	10.1

The figures for variance of species-number in the table represent the standard deviation of the mean species-number for each grouping, expressed as percentage of that mean. The smaller the variance, the more nearly alike are species-number results for different plots or units of one particular shape. It is seen that the most compact units (circles) give least variable species-numbers. The least compact units (strips, 66 by 528 feet) are considerably more variable. For greatest dependability, circular plots are recommended, but where the units must be contiguous, squares or short oblongs are nearly as good.

The differences in mean species-number per unit when units vary greatly in shape or degree of compactness, are believed to be real. Any tendency toward aggregation of several or numerous trees of one species into a clump might give such a clump heavier representation within a compact unit than within a narrow strip, thus tending to make less room for other species inside the compact unit. For reconnoissance surveys, line or strip methods thus seem to offer an advantage in disclosing a larger proportion of the total number of species.

A great and unpredictable variability in number of individual trees in different units of whatever shape, shows in one of the columns. It is presumably due to uneven distribution of size-classes in an all-aged mixed stand, particularly since some species are mostly very small trees (e. g., papaw). Species-number is thus a more tractable object of statistical study than is the number of individual trees.

A search for the species of *general* distribution throughout the areas sampled was made by selecting the species of 100 per cent frequency in 0.8-acre units of the four groupings tabulated above. Only five species were found in *all* 0.8-acre plots. These are: hard maple, the two elms, linden, and blue ash. Correlation with order of abundance is not very good. White ash (No. 3 in abundance) is missing from fair-sized areas in the woods. Blue ash, though in every 0.8-acre plot, is only No. 11 in abundance.

So far as adequacy and economy of sampling are concerned, it was very evident that many scattered small plots are superior to a consider-

ably larger number of contiguous plots (or in other words, to one large plot of greater total area). Dispersion of sample areas is indispensable for an adequate representation of the stand. The 0.2-acre size is recommended for small plots, since it gives a much better representation of species (mean no. for 0.2 acre 8.12, range 5 to 11; for 0.1 acre, mean 5.38, range 2 to 9). Also, 0.2-acre plots are much less variable.

The 10-acre total (one-sixth of the stand) is considered inadequate as a sample of the woods as a whole. Twelve acres dispersed in 60 plots may be suggested. The unexpectedly large size of an adequate sample, and the greater size of minimal area than was expected, are considered to be an expression of great variability in composition of this highly mixed forest community. It is submitted that a forest with numerous tree species is very different from the supposedly uniform association which from a distance it may appear to be. Ecologists frequently credit such forests with too high a degree of uniformity.

High content of soil organic matter, dominance in an earlier stage of bur oak, elm, and yellow oak, and complete *absence* of white oak, are attributed to a history of development from prairie upland only a few hundred years ago. Such forests in this part of Illinois are thus very different from those usually referred to the oak-hickory type.

Floral Zones in the Mountains of Southern Mexico

A. C. Noé

University of Chicago
Illinois State Geological Survey

ABSTRACT

During a collecting trip in southern Mexico in September, 1935, I had an unusual opportunity to observe the zones of the living floras of those regions. I went by bus from Mexico City to Puebla and Tehuacan in the state of Puebla, hired a Ford car in Tehuacan and went in it as far as Huajuapam in the state of Oaxaca, from where I proceeded, on horseback, to the former property of the Oaxaca Coal and Iron Company on the Rio Consuelo. This locality had been visited before in 1909 by G. R. Wieland, who made an extensive collection of fossil plants in the state of Oaxaca. During this trip it was possible to pass through cultivated tropical vegetation in the valleys (about 5000 feet above sea-level), through extensive cactus forests at an elevation of 6,000 to 7,000 feet above sea-level, to oak forests at 7,000 to 8,000 feet altitude, to a tropical alpine zone between 8,000 and 11,000 feet. The cultivated tropical vegetation in the valleys consisted primarily of banana trees, sugar cane, rice, avocado pears, bamboo, pineapple, cocoa nut palm, and tropical garden flowers. In the cactus zone we find a great variety of species of *Opuntia, Cereus, Cephalocereus, Echinocactus, Euphorbia, Yucca, Prosopis,* and *Beaucarnea.* The oak zone is primarily occupied by *Quercus mexicana,* near rivers also *Taxodium mucronatum.* Mixed with these are Arbutus and various species of ash tree. In the pine zone the predominance is of *Pinus montezuma,* often with *Tillandsia tricolor,* a Bromeliacea, growing on it.

Of the fauna I saw comparatively little in the mountain land of southern Mexico. There were plenty of lizards on the ground, but I saw no snakes. Coyotes could be heard during the night, and I saw, at short distance, a big wolf. One night a lynx crossed the road in the automobile lights. Among birds was noticeable the *Scoleporus fornosus,* with a back of emerald color, belly of dark blue, and throat of bright orange. There were also blue jays and turkey buzzards.

Was There an Outbreak of Bacterial Wilt of Corn in Central Illinois in 1891 and 1892?

Neil E. Stevens

University of Illinois, Urbana, Illinois

An apparent correlation between the temperature of the winter months at various stations in the northeastern United States and the prevalence of bacterial wilt of corn in this region was pointed out in a paper published in October, 1934. In the course of the study on which this publication was based, the writer had a number of conferences with Dr. W. H. Larrimer, then of the Division of Cereal Insects of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture. During one of these, Dr. Larrimer called attention to the following statement regarding the distribution of *Chaetocnema pulicaria,* on pages 109 and 110 of the Twenty-third Report of the Illinois State Entomologist, S. A. Forbes, published in 1905, which, because of its brevity and special interest is quoted nearly in full:

"In various years, but especially in 1891, reports of marked injury to corn by this flea-beetle came to us from many Illinois localities, in twelve different counties. About Jacksonville it appeared in corn fields within a radius of thirty miles from town. Whole fields were wilted more or less, and some hills entirely killed. As many as forty beetles were counted on one hill. An infested field near Manchester, in Scott county, was visited by an assistant July 19, 1892. The beetles were quite abundant in it, and the corn was very small (not over ten inches high) and pale and unhealthy looking. In 1891 similar injuries were recorded in Missouri and Indiana. In Maryland, in 1897, the first plantings of corn were ruined in parts of six counties. This flea-beetle seems especially fond of sweet corn, and also injures broom-corn and millet."

To anyone familiar with the disease, the description at once suggests bacterial wilt. The appearance of the fields, the fact that the sweet corn was most affected, and the fact that in Maryland the "first plantings" were ruined, all suggest this disease. Moreover, it has since been proved that this insect, *Chaetocnema pulicaria,* is one of those which carry *Aplanobacter stewarti,* the organism which causes bacterial wilt of corn. The accuracy of the records regarding the abundance of this insect in these years is, of course, unquestioned; the suggestion is merely that then, as now, it was carrying the bacterium and that part of the damage to the corn was due to bacterial wilt. Moreover, since the report above quoted was published in 1905, it seems fair to assume from the

statements that this insect was much less abundant in central Illinois in the years between 1892 and 1905 than it was in the years 1891 and 1892. The undoubted ability of Forbes and his associates as field observers, makes it all but certain that if *C. pulicaria* had become very abundant during any of the later years they would have seen and reported it.

Further indication of the probability of an epidemic of this disease having occurred in central Illinois in 1891 may be found in the weather records. The writer has elsewhere called attention to an apparent correlation between winter temperatures and the abundance of bacterial wilt.[1]

In these earlier publications it was suggested as a working hypothesis, that bacterial wilt would usually be absent following winters with a temperature index below 90 and present in destructive amounts following winters with an index above 100, with intermediate conditions following winters with an index between 90 and 100, and that a series of warm winters would be worse than a single one. Winter temperature index, as used here, is a simple summation of mean temperatures for December, January, and February. The following table gives this index for each year, 1890 to date for Springfield, Illinois.

TEMPERATURE INDICES (SUMS OF MONTHLY MEANS) AT SPRINGFIELD, ILLINOIS FOR THE WINTERS PRECEDING THE GROWING SEASONS OF THE YEARS INDICATED

Year	Index	Year	Index	Year	Index	Year	Index
1890	122	1902	74	1914	94	1926	93
1891	98	1903	84	1915	87	1927	95
1892	94	1904	70	1916	87	1928	92
1893	70	1905	69	1917	82	1929	80
1894	86	1906	94	1918	67	1930	90
1895	76	1907	97	1919	105	1931	105
1896	96	1908	94	1920	78	1932	117
1897	93	1909	98	1921	104	1933	101
1898	92	1910	76	1922	92	1934	97
1899	74	1911	95	1923	93	1935	94
1900	89	1912	74	1924	93	1936	67
1901	88	1913	92	1925	89		

It will be noted that the winter preceding the summer of 1890 was the warmest for the entire period, that the index for the next winter was almost 100, and for the winter preceding the summer of 1892, was well above 90, while the next winter was notably cold, having the lowest index prior to 1904. In accordance with the hypothesis mentioned above and recent experience in the eastern states, one would have expected bacterial wilt to be bad during 1890, probably even worse in 1891, still abundant in 1892, and negligible in 1893. This is in accor-

[1] Stevens, Neil E., Stewart's Disease in Relation to Winter Temperature: Plant Disease Reporter, 18:141-149, 1934.

dance with the facts so far as known. Moreover, the whole picture corresponds closely with what occurred in the northeastern states a few years ago, as shown by the accompanying tables.

RELATION BETWEEN WINTER TEMPERATURES AND ABUNDANCE OF FLEA BEETLE IN CENTRAL ILLINOIS

Year	Winter index at Springfield	Abundance of Flea Beetle
1890	122	(No record)
1891	98	Highest of any year
1892	94	High but less than previous year
1893	70	Probably scarce

RELATION BETWEEN WINTER TEMPERATURES IN SOUTHEASTERN NEW YORK AND ABUNDANCE OF BACTERIAL WILT

Year	Winter index at West Point	Abundance of Bacterial Wilt
1932	108	Very bad
1933	99	Highest of any year
1934	70	Only a trace—No commercial loss

It is tempting to speculate on the possibility that winter temperatures affect the abundance of the flea beetle directly and that this accounts at least in large part, for the fluctuations in bacterial wilt. There is, however, as yet no evidence of that. In fact, we have been unable to find any adequate eastern record of the abundance of *Chaetocnema pulicaria* during the critical years of 1932, 1933, and 1934, which is one of the unfortunate results of the fact that those of us who do field work, habitually confine our observations to so few natural phenomena. This is almost pathetic, as is the fact that the student of the history of plant disease is driven to use such fragmentary clues as these here discussed.

An Interesting Preservation of Color in the Algae and Certain Fungi

E. L. Stover

Eastern Illinois State Teachers College, Charleston, Illinois

Every teacher of botany is interested in preserving the natural color of plants that must be used as specimen materials when living specimens are not available.

Several years ago I showed that certain colors of fungi may be preserved by using pure glycerine as a preserving fluid. Species of red algae and red and green *Discomycetes* have retained their natural colors for months and even years. The best results with this solution were obtained with *Peziza* spp., *Plectania occidentalis, Sarcosypha floccosa,* and *Leotia chlorocephala.*

Recent experiments have shown that weak solutions of formaldehyde and paraformaldehyde may be used to better advantage because of lower cost and because they do not have the clearing effect of glycerine.

Living sea algae removed from the sea water and placed in a two and one-half per cent solution of formaldehyde will retain their natural colors, green, brown, and red for varying periods of time. All will remain brilliantly colored for days and even weeks. *Agardhiella* sp., *Ceramium* sp., *Polysiphonia* sp., *Lophosiphonia* sp., *Ulva, Monostroma,* and *Fucus* have kept their colors in such solution for more than a year. Several fungi have been tried but not with marked success.

A five per cent solution of paraformaldehyde promises to be an even better preserving medium for the above mentioned forms, and even the fresh-water green algae have retained their natural green color for several weeks in this solution. *Spirogyra* sp., *Cosmarium* spp., *Oedogonium* sp., and *Hydrodictyon* sp. have all been treated with this solution. Examination shows practically no plasymolysis of the cells of these green fresh-water forms.

Bright sunlight causes certain forms to gradually loose their color, however, if they are not allowed to remain in bright sunlight they retain their natural colors for weeks and months.

Experiments with the leaves and flowers of the higher plants have so far not been successful except for short periods of time. Further experiments are now being made with all of these plants.

It is hoped that this report will interest other botanists and that they will try various concentrations of the paraformaldehyde with various species of all groups of plants.

The paraformaldehyde (C. P.) may be obtained as a white powder and dissolved in distilled water at room temperature. It is very slowly soluble and requires frequent shaking.

Ref: Stover, E. L., A Method of Preserving the Natural Color of Certain Fungi. Trans. Ill. Acad. of Science, Vol. 21, p. 187, Feb., 1929.

Reduction in the Number of Trees in Maturing Pine Forest

Lewis M. Turner

University of Arkansas, Fayetteville, Arkansas

There are relatively little quantitative data on the annual or period reduction in the number of trees in developing forest. It is well known, of course, that many trees die, succumbing to the effects of competition, during the time of forest maturation. In the case of tree species which bear many viable seeds and produce many seedlings, the number of trees which come to maturity may be an exceedingly small percentage of the original number of young trees in a given area. This paper summarizes the results of an investigation of this question in relation to a single species, the southern shortleaf pine.

Competition among individuals within a species is well illustrated by the southern shortleaf pine, *Pinus echinata* Miller. Throughout Arkansas, exclusive of the river overflow areas, pure stands of various ages of this tree may be found. Most of these pure pine forests are doubtless on areas that were once cleared, for agriculture, in lumbering operations, or on sites in which the original (usually mixed pine-deciduous) forest was destroyed by tornadoes. Such stands are essentially even-aged. It is a characteristic of both shortleaf and loblolly pine to invade and pre-empt bare areas quickly. Such areas are stocked with seedlings, in numbers permitted by the factors of the sites, in from one to five years.

Method of study.—In this investigation, counts were made of trees in twenty-three unmolested stands of shortleaf pine of various ages. All plots of trees 35 years of age, or older, were 1/4 acre in area; younger trees were counted on 1/16-acre plots. Average height, diameter, and age of dominant and co-dominant trees was secured with the usual instruments. All plots were on Hanceville sandy loam with a slope of approximately 20 per cent. The character of the soil is significant since the rate of growth is materially influenced by soil features, and possibly the number of trees per unit area at any given age would also be influenced by this factor. Hanceville sandy loam, with slope around 20 per cent, affords a relatively poor pine growing site, having a site index of about 50, or an average height growth of about a foot a year during the first 50 years. Superior sites for this species afford a growth rate of about two feet a year.

Results.—The following table shows the relationship of age of the shortleaf pine stands to the number of trees per acre, and to the average height and diameter, of dominant and co-dominant trees:

TABLE I.—THE RELATIONSHIP OF AGE OF STAND TO THE HEIGHT, DIAMETER, AND NUMBER OF TREES PER UNIT AREA OF SHORTLEAF PINE ON HANCEVILLE SOIL

Number of stands from which averages were determined	Average age of trees	Diameter* breast height	Height of trees	Number trees per acre	Per cent annual reduction of trees during periods
1	9 yrs.	1.9″	6.0′	19,008	.....
2	16 yrs.	2.8″	14.0′	8,783	8.0
2	35 yrs.	6.0″	40.0′	1,638	2.0
4	40 yrs.	8.5″	44.0′	744	0.9
5	60 yrs.	9.6″	60.0′	415	0.08
3	70 yrs.	12.0″	66.5′	180	0.12
5	116 yrs.	14.3″	78.0′	120	0.07
1	152 yrs.	17.0″	85.0′	80	0.058

* Diameter and height averages are of dominant and co-dominant trees.

As would be expected the greatest mortality of trees occurs in the early years of the life of the stand. The period of seven years, from the ninth to the sixteenth, brought about a reduction of 54 per cent of the number in the nine-year-old stand, or an average annual diminution of 8.0 per cent. The next 19 years show an average annual loss of 2 per cent of the nine-year-old stand, and the next five years an average annual loss of 0.9 per cent. From the age of 35 years on to the time of maturity the average annual losses were small, compared to those of the early stages, being only 0.058 per cent per year, during the period between the 116 and 152 years. The number of individuals in the 152-year-old forest was 0.42 per cent of the number in the nine-year-old stand.

Barrens Vegetation in Illinois

Arthur G. Vestal

University of Illinois, Urbana, Illinois

In a recent search into descriptions of early conditions in Illinois, the writer was impressed by the frequency of mention of the *barrens*, and although very little botanical information about them was found, their former generality of occurrence was evident. One wonders what they may have been like and what became of them.

It is now recognized that the extensive barrens of Kentucky were in most cases outlying areas of prairie vegetation, and it seems plausible that some of the prairie uplands of southern Illinois, cut off from larger prairies by dissected and forested stream valleys, were sometimes labeled barrens instead of prairies, particularly if they were being invaded by sumac or hazel or by young trees. Very open stands of post oak with grassy ground-cover (there is reason to believe that post-oak flats were commonly of this character) might also have been known as barrens. Although cultivation has obscured part of the vegetational history, there are in Cumberland County and elsewhere, upland areas which (judging from soil-types) at one time were tree-covered, later perhaps (this before the days of white settlement), swept by fire, and then occupied by grassland plants. These however failed to include some of the most characteristic prairie herbs, such as the Silphiums. These areas also differ from normal prairie by the frequency or local dominance of plants usually occurring in the herbaceous ground-cover of open forest or of glades, for example *Danthonia spicata*. This is definitely a grassland, but a grassland with an unusually high proportion of forest herbs, and lacking many prairie plants. Such vegetation might have been recognized by discriminating early residents and travelers as barrens rather than prairie. There seems to be no good reason why present-day remnants of it should not today be recognized as a survival of at least one kind of barrens vegetation.

With the several types of mixed forest and prairie vegetation representing replacement of disturbed prairie by forest, and with varieties of areas in stages of reforestation following burning or clearing, we are not primarily concerned, though many of these were given the term barrens.

We therefore concentrate upon treeless upland areas dominated by grasses or by grassland containing numerous dicot herbs, which for one or another reason differs from prairie vegetation as commonly recognized in the early days and at present. Rolling hill areas in the south-

ernmost counties as well as in Marion county were described as barrens by Henry Engelmann in the 1860's. Their progressive replacement by forest was considered by him as likely to be completed within relatively few years. One reason for the former common recognition of barrens and the present unawareness even of their former existence may thus be that such barrens have long ago passed out of the picture, partly from extension of agriculture, partly from encroachment of forest as witnessed by Engelmann. His "tall barren grass" is believed by some botanists to be an Andropogon.

Lewis C. Beck, between 1823 and 1828, described barrens near St. Louis, some on the Illinois side of the Mississippi. Forest (and prairie) herbs listed by him as occurring in barrens include some of the plants which today can be observed as common species of forest openings, forest borders, cut-over areas of xeric forest, and of forested narrow spur-tops exposed to sun (also to wind: thus kept free from a cover of dead tree-leaves). These also come to occupy strip-mine ridges, road-cuts, cut-over sunny hillsides, and railroad rights of way in forested country. They are common in some abandoned fields, particularly on hill-tops of the Illinois Ozarks. Many such areas will become forested, but many others give indications of continuing as a semi-natural grassland of indefinite tenure. These are the present-day barrens.

The plant list includes perennial sunflowers, asters and goldenrods, Antennaria, numerous other composites, prairie grasses (which are grasses of the forest region also in most cases), Ceanothus, *Baptisia leucantha,* Potentillas, Lespedezas, Tephrosia, Desmodiums, Gerardias, Frasera, Pycnanthemums, Pteris, xeric sedges.

Attention of botanists is invited to modern barrens. Economic ecologists will also do well to study them. Here is already at hand a selection of the hardiest native plants for use in soil conservation, particularly in erosion control.

A Comparative Study of Bogs on Cary and Tazewell Drift

John Voss
Peoria, Illinois

ABSTRACT

Pollen diagrams of the Valparaiso bogs practically reveal a complete picture of the forests of post-Valparaiso times in Illinois. Unfortunately, the forest history of the post-Bloomington period is less complete, due to the absence of satisfactory pollen records in the upper layers of the Tazewell bogs.

The succession of forests as shown by the pollen diagrams of bogs of both substages apparently is the same in most cases: (1) Increase and dominance of the conifers; (2) decline of the conifers and the advance of the deciduous forest. If the oldest layers of the Tazewell peat formed very slowly, the period of conifer dominance of that stage may coincide with the period of conifer dominance following the retreat of the Valparaiso ice. On the other hand, the post-Bloomington conifer forests might have been superseded by the deciduous forests before the advance of the Valparaiso ice-sheet, and the succession of forests in central Illinois since Bloomington times may have been as follows: (1) northern conifer, (2) deciduous, (3) northern conifer, (4) deciduous.

Evidence supporting the theory of a xerothermic period during postglacial times is lacking.

PAPERS IN CHEMISTRY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

Twenty-three papers were presented in a two-section meeting of the Chemistry group. The six that are not here represented were as follows:

New Analytical Reagents (demonstration), by G. F. Smith, University of Illinois, Urbana.

The Application of Chemical Research to the Problems of the Illinois Mineral Industry, by F. H. Reed, Illinois State Geological Survey, Urbana.

An Improved Apparatus for the Demonstration of the Fixation of Atmospheric Nitrogen (demonstration), by W. S. Haldeman, Monmouth College, Monmouth.

The Application of Modern Valence Ideas to the Teaching of Chemistry, by John DeVries, Knox College, Galesburg.

Some Recent Models of the Periodic Table, by B. S. Hopkins, University of Illinois, Urbana.

Some Home-made Apparatus for the Teaching of the Ionization Theory, by H. P. Leighly, Rantoul High School, Rantoul.

Attendance at the meeting was about one hundred and twenty-five.

Dr. W. F. Bailey, MacMurray College, Jacksonville, Illinois, was elected chairman of the Chemistry Section for the 1937 meeting.

(Signed) J. H. REEDY, *Chairman*

Some Interesting Methods of Balancing Oxidation-reduction Equations

C. W. Bennett

Western Illinois State Teachers College, Macomb, Illinois

During the past few years the writer has made a sort of hobby of the subject of balancing equations. During the years 1931-1934 there was a continuous series of correspondence on the merits of the various methods in the Journal of Chemical Education. Nothing was settled as to the best method of balancing equations, but it is the opinion of the writer that the valence-change method (1) is the most rapid and dependable while the ion-electron (2) method is the most in keeping with our modern knowledge and the most instructive, but a little tedious. A third method which is always interesting to students and teacher alike is the algebraic method (3). The latter method is hardly suitable for use but has in it an element of surprise because few people realize that complex equations may be accurately balanced by mere algebra without recourse to valence considerations of some kind.

Let us select a sample equation such as: $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO + H_2O$ and balance it by each of the methods.

Algebraic method.—This method is based on the assumption that there is a certain number of Cu atoms which we may designate as a; then b HNO_3, etc. Our equation becomes: a Cu + b HNO_3 → c $Cu(NO_3)_2$ + d NO + e H_2O now for:

Cu	a = c
H	b = 2e
N	b = 2c + d
O	3b = 6c + d + e

Since b = 2e, for the N equation, we have: 2e = 2c + d and for the O equation 6e = 2c + d + e or 5e = 6c + d. Subtracting the first equation from the last, we have: 3 e = 4c, whence e = 4/3c.

Let c = 1, then: a = 1, e = 4/3, b = 8/3, and d = 2/3.

To remove fractions multiply all coefficients by 3. Then: a = 3, b = 8, c = 3, d = 2, and e = 4, resulting in the orthodox equation:

$$3\ Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$$

As H. G. Deming (4) points out much time can be saved by eliminating two of the unknowns at the start since a = c and b = 2e.

Valence-change method.—The valence-change method is so commonly used that there is little need to go into detail beyond the statement that a mutually consistent set of valences is assigned to the ele-

ments and from these and the change these valences undergo, a relationship can be set up between the number of molecules of oxidant and reductant. These valences, while not always consistent with our modern knowledge, do lead to rapid, accurate results. In our chosen equation the valence of Cu changes from 0 to 2 in $Cu(NO_3)_2$, a gain of 2, while that of N changes from 5 in HNO_3 to 2 in NO, a loss of 3. To equalize this gain and loss, 3 coppers and 2 nitrogens which change valence are needed. The remainder of the equation is quickly balanced by inspection.

Ion-electron method.—The ion-electron method, while very complicated, has great teaching value. The equation is divided into two partial equations, one for the oxidant, and one for the reductant, using only the ions which are really concerned in the equation. These must be balanced first atomically and then electrically:

oxidant $4H^+ + NO_3^- \rightarrow NO + 2H_2O$

There are now 4 pluses and 1 minus on the left, making an excess of 3 pluses which may be balanced electrically by the addition of 3 electrons:

$3e + 4H^+ + NO_3^- \rightarrow NO + 2H_2O$

Similarly for the reductant:

$$\overset{0}{Cu} \rightarrow Cu^{++} + 2e$$

Since we have 2e and 3e, we must reach the lowest common multiple 6 by multiplying the oxidant equation by 2 and the reductant equation by 3 and then add:

$$6e + 8H^+ + 2NO_3^- \rightarrow 2NO + 4H_2O$$
$$3Cu \rightarrow 3Cu^{++} + 6e$$
$$\overline{3Cu + 8H^+ + 2NO_3^- \rightarrow 3Cu^{++} + 2NO + 4H_2O}$$

The equation is now balanced but to be orthodox it should have 6 more nitrate ions on each side. It is seen by the example that the ion-electron method makes no arbitrary assumptions of valence and stands the test of our modern thinking. It may fail to achieve the popularity it deserves due to the fact that it is cumbersome.

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Chemistry in Highway Construction

Fred A. Dykins

Engineering Chemist
Division of Highways, Springfield, Illinois

The Division of Highways of the State of Illinois, in its Bureau of Materials at Springfield, maintains a completely equipped chemical laboratory. The principal work of this laboratory is the analysis of the materials used in the construction and maintenance of the highways. The laboratory also develops procedures for testing materials, investigates new types of material, and assembles data for use in the preparation of specifications.

The new laboratory building, constructed in 1934, is modern in every respect and has six well appointed laboratory tables. The general equipment includes Chainomatic balances, constant temperature ovens, electric muffle, centrifuge, Barnstead still, constant temperature water baths, combustion apparatus, constant humidity cabinet, microscope, refractometer, potentiometer, tintometer, Soxhlet extractors and electrolytic apparatus. Equipment for testing refinery products includes thermostatic viscosimeters, ductility machine, New York Testing Laboratory penetrometer, Tag closed tester, gasoline distillation apparatus, Dulin rotarex and Union colorimeter. Recent additions to the laboratory equipment are a Precision penetrometer, a Hubbard Field asphalt stability testing machine, and a Frigistat for cloud and pour point determinations which can reduce the temperature to –70°F.

All materials purchased by the Division of Highways are required to comply with carefully prepared specifications which are published as the Standard Specifications for Road and Bridge Construction. Chemical analyses are made of representative samples of all of the materials which are to be used for construction and maintenance. These samples are classified into four groups and the types of tests are designated as Quality Tests, Preliminary Tests, Acceptance Tests, and Check Tests.

Samples for Quality Tests are representative specimens of material which are subjected to detailed investigation in order to obtain as much information as possible concerning the quality of the product. Samples for Preliminary Tests are representative specimens of materials submitted by manufacturers and producers in order to secure information concerning the suitability of their products for the work of the Division of Highways. The results of these tests are useful in locating possible sources of supply for quality products.

Samples for Acceptance Tests are representative specimens of materials which are to be used in the construction and maintenance of the

highways. These samples are always taken by an official representative of the Division of Highways and are tested for compliance with the particular specifications under which they were purchased. Analyses of such samples are the major part of the work of the laboratory. Samples for Check Tests are representative specimens of materials which may not appear satisfactory when received at destination. Check Tests are also made on materials which have been stored for some length of time, and on materials which have been accepted at the place of manufacture by an inspector working away from the Springfield laboratory.

During the past year nearly four thousand samples were tested by the laboratory, representing 300 types of materials (Table I).

TABLE I.—CHEMICAL LABORATORY, CALENDAR YEAR 1935

Material	Number of samples					Quantity tested
	Quality	Prelim.	Check	Accept	Total	
Asphalt—Cement	87	6	25	548	666	8,300 tons
Cut-back	.....	.....	.....	.....	.....	1,350,000 gals.
Bituminous Joints and Planks	.....	1	.....	204	205	850,000 lin. ft.
Bituminous Mixes	26	1	4	298	329	14,000 tons
Calcium Chloride	.....	.....	.....	33	33	1,100 tons
Cement	1	.....	374	24	399	1,900,000 bbls.
Creosote Oil	.....	1	3	96	100	500,000 gals.
Galvanized Materials	5	.....	135	10	150	2,000 tons
Lubricants	9	.....	4	378	391	62,000 gals.
Paint Materials	9	4	1	330	344	46,000 gals.
Road Oils	4	1	1	978	984	11,600,000 gals.
Tars	1	1	41	125	168	800,000 gals.
Miscellaneous	47	7	3	146	203	
Totals	189	22	591	3,170	3,972	

When materials such as refinery and paint products are purchased in large quantities during a short period of time, an inspector goes directly to the plant and tests the product during the progress of the manufacture. Such a procedure is convenient for the Division of Highways, the contractor and the materials producer and gives assurance that all the materials produced and shipped to the construction site comply with the specifications under which they were purchased. Check Tests on these materials are made in the Springfield Laboratory.

In addition to the materials tested for the Division of Highways and State Aid work, samples are also tested for other State Departments and the various counties, townships and cities of the State. Recently the laboratory has tested materials used for roads built under the N. R. A., the P. W. A., and the W. P. A. The laboratory cooperates with the Highway Laboratories of other States and the U. S. Bureau of Standards.

Some Anomalous Properties of Organic Fluorine Compounds

G. C. Finger and Frank H. Reed

Illinois State Geological Survey, Urbana, Illinois

The abundance of fluorine is three times that of copper and fifteen times that of lead in the earth's crust. In spite of this abundance, the chemistry of fluorine compounds is the least understood of the common elements because of the extreme reactivity of the element and the extremely toxic and corrosive properties of many of its inorganic compounds. A number of inorganic fluorides are very well known but practically nothing is mentioned in the average college textbook on the organic compounds.

The advent of Freon (dichlorodifluoromethane) as a new refrigerant in 1930 signalized a new epoch in synthetic organic fluorine chemistry, especially in the commercial world as it refuted the traditional concept that all fluorine compounds are either corrosive or toxic or difficult to prepare. Other refrigerants, new non-fading dyes, solvents, electrical condenser insulators, etc., containing fluorine have made their appearance and for certain purposes are superior to anything else that is available. Unfortunately the chemistry of these compounds is scattered throughout the scientific and patent literature and has never been correlated or compiled in any single publication.

Very few of the general methods of synthesizing organic halides are applicable to fluorine compounds. Direct fluorination takes place with explosive violence and with the disruption of the molecule due to the high heat of reaction which is much greater than that of the "Thermite" process. The usual products of direct fluorination are a mixture of organic fluorides, carbon, and hydrogen fluoride although an excess of fluorine gives carbon tetrafluoride. The treatment of an alcohol with hydrogen fluoride gives an equilibrium mixture of the alkyl fluoride and ether. The reaction of PF_3 with an alcohol gives phosphorous esters. The addition of HF to an olefine has not been reported in the research literature, however, a patent has been issued using propylene as an example to give a propyl fluoride. This leaves two general methods of synthesis, (1) the replacement of a halogen atom by fluorine through reaction with certain anhydrous metallic fluorides (AgF, Hg_2F_2 or HgF_2, TlF, ZnF_2, and SbF_3) depending upon the compound desired,

$$RX + MF \rightarrow RF + MX$$

and (2) the introduction of fluorine into an aromatic nucleus by the

decomposition of a diazonium compound,

$$C_6H_5NH_2.HF \xrightarrow{HONO} C_6H_5N_2F \longrightarrow C_6H_5F + N_2$$

$$C_6H_5NH_2.HX \xrightarrow{HONO} C_6H_5N_2X \xrightarrow{HBF_4} C_6H_5N_2BF_4 \xrightarrow{heat} C_6H_5F + N_2 + BF_3$$

The new refrigerant dichlorodifluoromethane (commercially called Freon) and some of the new solvents and dyes are made by the first reaction with SbF_3 under heat and pressure with $SbCl_5$ as a catalyst. In the laboratory some of these reactions can be carried out in glass with considerable etching or in platinum but commercially monel metal, copper, and iron serve very well if certain precautions are taken.

The physical properties of the fluorine compounds are very unusual in comparison to the chlorine analogs. Their boiling points are much lower than the chlorine compounds and in a large number of cases lower than the parent hydrocarbons as illustrated in Table I; the melting points are also much lower. The odor of many of them is much milder and the compounds less toxic. Organic solvents readily dissolve them and they themselves possess unique solvent properties. Hydrogen fluoride is highly associated but in general the organic fluorine compounds are not. Many of them exhibit low inflammability and low corrosive properties making it possible to work in ordinary equipment without unusual hazardous conditions. The fluorinated acetic acids, especially trifluoroacetic acid, are as highly ionized as our strong mineral acids, and the fluoroalcohols also show definite acidic properties.

TABLE I.—THE EFFECT OF FLUORINE SUBSTITUTION UPON THE BOILING POINTS OF ORGANIC COMPOUNDS

Compounds	B. P. °C.	Compounds	B. P. °C.	Compound	B. P. °C.	Compound	B. P. °C.
CH_4	−164.7	CH_3F	− 78	CHF_3	−2/20 atm.	CF_4	−128
CCl_4	76	CCl_3F	24.1	CCl_2F_2	−28	$CClF_3$	− 80
CH_3COCH_3	56.5	CH_2FCOCH_3	72	CHF_2COCH_3	46.2	CF_3COCH_3	21.9
CH_3COOH	118.1	CF_3COOH	72.4	CCl_3COOH	195	CBr_3COOH	245
CH_3CH_2OH	78.4	CH_2FCH_2OH	103.3	CHF_2CH_2OH	96	CF_3CH_2OH	74
C_6H_6	80.4	C_6H_5F	85	C_6H_5Cl	132	C_6H_5Br	156
$C_6H_5CH_3$	111	$C_6H_5CF_3$	103.5	$C_6H_5CCl_3$	214	$C_6H_5CBr_3$	.....

The chemical properties of these compounds are as unusual as their physical characteristics. In general they are more stable than their chlorine analogs, reaching a maximum when the carbon atom carrying the fluorine contains no hydrogen as in the case of the $—CF_3$ group. This group will resist hydrolysis by water, alkalies, and acids almost indefinitely even under the most severe conditions. The aliphatic monofluorides are quite sensitive to fuming nitric and concentrated

sulfuric acids. The acid fluorides are very much like the aromatic sulphonyl chlorides in stability. The organic fluorine compounds resist reduction to an almost unbelievable degree. For all practical purposes they do not corrode such metals as copper, monel, nickel, iron, and they will not form the Grignard reagent, and with sodium in liquid ammonia they form sodium fluoride which is used as a basis for analysis. In some cases the fluorine atoms may be activated by other substituents such as in the case of chloroacetyl fluoride which hydrolyzes very rapidly due to the chlorine substitution. Benzotrifluoride ($C_6H_5CF_3$) can be nitrated almost quantitatively to the meta nitro benzotrifluoride, which in turn will not hydrolyze even under strenuous treatment. Since the $-CF_3$ group in an aromatic compound has a similar effect as a nitro group on color this type of compound is commercially used in a few non-fading dyes. Some of the highly substituted chlorofluorine liquid compounds are excellent electrical insulators due to their extreme stability, high di-electric constants, and low viscosity changes with ordinary temperatures.

The analysis of organic fluorine compounds is very difficult and the best known methods still leave much to be desired as far as accuracy, applicability, and ease of manipulation is concerned. There are about as many modifications on analysis as there are original papers on new fluorine compounds. The determination of carbon and hydrogen in a compound necessitates packing the combustion tube with special materials for complete oxidation and also for the retention of the fluorine. Fluorine is usually analyzed by two methods, (1) the Na_2O_2 bomb fusion method, and (2) the sodium-liquid ammonia method of Nieuwland. Both methods require highly refined technique for accuracy although the latter is rapidly gaining favor because of its simplicity and non-hazardous manipulation. After the organic fluorine has been converted to an inorganic fluoride, the problem evolves into choosing a method with the smallest correction factor.

Corrosion Characteristics of SiO_2-Al_2O_3-CaO-MgO Glasses

Charles F. Fryling and Fay V. Tooley
Illinois State Geological Survey, Urbana, Illinois

Introduction.—Preliminary to the recent work on the rock wool resources of Illinois carried out in the Geological Survey laboratories[1], a series of four component (SiO_2-Al_2O_3-CaO-MgO) silicate melts were prepared, utilizing the pot fusion method of Peddle[2]. An accurate investigation of glass, as shown by Morey[3] and others[4], requires the use of platinum apparatus, but the work is slow because only one sample can be prepared at a time. Peddle has demonstrated, however, that much useful information on glass characteristics can be obtained from glasses prepared by fusion of batch mixtures in clay pots[2]. As an initial step toward a more thorough and accurate investigation, the clay pot fusion method can be said to embrace practical advantages, as it is possible by such means to prepare more glasses simultaneously, and these in larger quantities, than is allowed by the high cost of large platinum ware, and the small size of crucibles usually available.

The chief difficulty encountered in the pot fusion method is the corrosive effect of certain batch compositions on the pot, a condition which of course disturbs radically the original composition in the finished melt. Pot corrosion is a function principally of three interrelated factors: (1) phase equilibrium relationship involving the components in the batch and pot; (2) viscosity of the melt of the original batch composition and the change in viscosity with change in melt composition due to corrosion, and (3) the duration of time that the melt is kept in a fluid condition. The porosity of the pot and surface tension of the melt are additional factors in the corrosion process. Our data can be discussed to only a limited extent on a basis of above factors because phase equilibrium data on the four-component system under discussion are not as yet complete in the literature, and all the melts were prepared under the same conditions and hence depart from true equilibrium in different degrees. Some observation on a basis of viscosity is afforded, however, as some of the original batch compositions studied were similar to the composition of certain basic slags utilized in viscosity studies by McCaffery[5] and his co-workers.

We have found, as a result of preparing a great number of silicate melts of the system cited, that batches containing in excess of 70 per

cent $SiO_2 + Al_2O_3$, or in excess of, 1.15-1.20 gram mols $SiO_2 + Al_2O_3$ per 100 gm. batch, can be melted in fireclay pots without excessive corrosion.

Experimental procedure.—Batch compositions were compounded from the raw materials (silica, aluminum hydroxide, calcium carbonate and magnesium carbonate) to give one kilogram of raw material per sample. Following thorough mixing, the samples were moistened with distilled water and packed tightly into fireclay crucibles (3 ½″ top diameter by 5 ½″ high), excess sample being discarded. After drying, the crucibles were transferred to a gas-fired kiln, fired to 1375° C, which temperature was maintained constant for two hours. After cooling for 20 hours the kiln was opened, the crucibles were drawn, and the melts were examined visually and analyzed quantitatively.

Experimental results.—Chemical analyses revealed that corrosion was excessive only in those samples containing less than 70 per cent silica-plus-alumina and that the corrosion varied fairly regularly with the silica-plus-alumina content (Table I).

TABLE I.—CRUCIBLE CORROSION AS A FUNCTION OF BATCH CONTENT OF SILICA-PLUS-ALUMINA

Batch content $SiO_2 + Al_2O_3$ per cent	Analyzed content $SiO_2 + Al_2O_3$ per cent	A. D. of analyzed $SiO_2 + Al_2O_3$ content per cent	Number of samples analyzed
70	71.7	± 0.9	17
65	68.1	1.3	19
60	65.8	2.0	19
55	65.3	3.1	15
50	64.7	2.3	7
45	65.9	3.4	6
40	68.4	...	1

Expressing extent of corrosion as a function of batch silica-plus-alumina on a mol basis indicated that samples containing in excess of 1.15-1.20 gram mols per 100 gms. of melt can be prepared by the pot fusion method without disturbing the originally desired composition radically.

Some few of the glasses prepared were of such composition that the viscosity both of the melt of batch composition and the melt of changed composition due to corrosion could be compared in a general way on a basis of the viscosity studies of basic slags by McCaffery and co-workers[6].

Such a comparison taking into consideration the other factors influencing corrosion, indicated the nature of the influence of viscosity. A low viscosity for a particular batch composition does not necessarily imply that excessive corrosion will take place; if that particular glass

composition is saturated with those components which it might dissolve from the pot, it can exhibit a low viscosity and still be comparatively non-corrosive. It is in those instances in which the original glass is unsaturated with respect to components of the pot that viscosity and time are factors of great magnitude. If in such a case the viscosity of the original melt is low and the duration of fusion long, corrosion approaching thermal equilibrium for the components of the pot and melt at the temperature employed will take place.

In conclusion it should be pointed out that while the use of platinum ware is certainly essential to the accurate investigation of such glasses, the batch process, utilizing fireclay pots for melting is of definite worth in the preliminary evaluation of silica-alumina-lime-magnesia glasses of certain restricted compositions as herein described.

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The Natural Chemical Resources of Southern Illinois

J. W. Neckers

Southern Illinois State Teachers College, Carbondale, Illinois

Illinois is widely noted for its agricultural products, but few people realize that its second most important contribution to commerce comes from its mineral resources. "Egypt"—the southernmost quarter of the state—has a greater variety of these resources than the other three quarters combined. From the discovery of salt deposits in Saline County by the earliest pioneers to the recent studies of the future possibilities of Anna kaolin, there has been a steady advance in the development of various minerals.

The most extensive deposits are those of soft coal which, until recently, were not of special chemical significance. However, in December, 1933, a coking plant using the Knowles type oven was put into operation at West Frankfort, the site of the largest soft coal mine in the world. At the present time twenty-six ovens are in operation, using over 330 tons of coal each day to produce 250 tons of a coke, called "Carbonite", several tons of a light tar, and about 750,000 cubic feet of gas which is bought and distributed by the Western United Gas and Electric Company. The coke is used chiefly for fuel purposes but developments may yield a product for metallurgical use.

The fluorspar deposits of Hardin County are noted as among the most productive mines the world over. Discovered in 1839, mining started in 1842 with galena, which was also present, receiving the most attention. After the Civil War the lead ore was gradually superseded in importance by the fluorspar and since 1900 it has been of major importance. During the last decade about 630,000 tons of fluorspar, valued at over thirteen million dollars, were marketed from these mines. Most of the ore is used in the basic open hearth steel process to give greater fluidity to the slag. Considerable quantities are also used by the aluminum industry in the manufacture of artificial cryolite, Na_3AlF_6; and for the preparation of other fluoride chemicals.

Another mineral of importance to several chemical industries is the fuller's earth deposit along the Ohio River in Pulaski County. Mining was started in 1920 by the Sinclair Oil Company and shortly after that date the Standard Oil Company of Indiana opened a second mine near by. About 150,000 tons of the earth, selling for over two million dollars, have been obtained since that time. The two plants have a

capacity of over 300 tons a day. Again Illinois ranks in the first three states in the Union in this product. It is used almost entirely for bleaching and clarifying mineral oils. Its action in this capacity is dependent upon the porous nature of the earth, due to the fact that it is built up of grains approaching colloidal size which offer a large active surface. (The name "fuller's earth" is derived from its original use in removing grease and fat from woolen cloth during the process of fulling.)

"Egypt" is also noted for its deposits of silica of a very high degree of purity, especially in Union and Alexander Counties. The mineral is ground to the fineness of flour and is used extensively as a filler in paint, wood and soap products, and in the manufacture of metal polishes and foundry molds. Production during the last decade amounted to 135,000 tons valued at over one and a quarter million dollars.

There are also numerous deposits of clays for use in the manufacture of pottery and lower grade ceramics products, and of limestone which, however, is used mostly as crushed stone for aggregate and ballast.

All of these natural chemical resources, with the exception of the by-product lead from fluorspar mining, are of non-metallic nature. They do not receive the publicity of the metal ores in other parts of the country but, nevertheless, they are all of national reputation in their particular fields. They are all contributors to success in important industries.

Two other possible developments are of great interest according to recent investigations of the State Geological Survey. First, the rapidly expanding rock-wool industry has at its demand five deposits of workable wool-rock material of siliceous limestone for the production of high-grade insulating products. Second, Illinois produces one-fourth of the edible animal and vegetable oils used in the United States. If the fuller's earth, previously described, is used for purifying these edible oils they become rancid, so it has been necessary to use English or Californian earths costing from twenty-six dollars to fifty-four dollars a ton with as much as 50 tons a day being used. It has recently been discovered that a kaolin deposit near Anna (Union County) has characteristics which may allow it to compete with these imported products. This Anna kaolin seems to have regenerative powers which excel both the others now in use.

The quality and uses of all these natural chemical resources of Southern Illinois are of a nature that point to an excellent continued demand in supplying the needs of a variety of essential industries. Discovery of new deposits and further developments should also lead to expansion in the productions of these minerals.

Titanium-Hydrogen Peroxide Compounds

D. G. Nicholson

University of Illinois, Urbana, Illinois

"After yellowing" of white paints and enamels has been a problem of importance to the paint and pigment manufacturers. Lithopone paints have a tendency to yellow when exposed to darkness (behind pictures, mirrors, etc.), while titanium dioxide whites have a tendency to yellow when exposed to light.

The yellowing of the titanium dioxide paints is explained by the fact that peroxide linkages formed at the unsaturated bonds in the vehicle during the drying process tend to oxidize some of the titanium dioxide to pertitanate, in which form the titanium is present in a valence form higher than four.

A study conducted using anhydrous ethyl acetate as the solvent with titanium tetrachloride and anhydrous hydrogen peroxide as solutes has shown that an addition product is formed between the two compounds. This addition compound is insoluble in the ethyl acetate solution. Upon standing at room temperature or upon contact with water the material changes from white to the orange red of pertitanate material. The decomposition is accompanied by liberation of oxygen, hydrogen chloride and water. The water formed in this decomposition evidently serves to cause some dissociation resulting in the orange-red colored surface. The white material is very soluble in water producing the red-orange aqueous solution of pertitanate. The white compound is evidently a coordinated compound containing titanium chloride and hydrogen peroxide.

Since paint films are virtually anhydrous in nature, it follows that the yellowing of the titanium dioxide films could be attributed to a peroxide coordination between the peroxide linkages in the vehicle and the titanium dioxide particles in the film, rather than a true oxidation of the titanium dioxide molecule in the semi-solid film. This coordination or yellowing is catalysed by light as well as moisture.

Laboratory tests made using titanium hydroxide and a solution of dry hydrogen peroxide in ethyl acetate show an immediate definite yellowing of the titanium dioxide particles. This same yellowing effect is also observed when air is bubbled through a suspension of titanium hydroxide in turpentine for a period of two weeks or longer.

Present and Future Energy Sources

H. E. Phipps

Eastern Illinois State Teachers College, Charleston, Illinois

The world is now using energy supplies at an almost unbelievable rate. In the last fifty years, the production of coal increased 736 per cent, natural gas, 2166 per cent and oil, 3346 per cent in the United States. Similarly the installed horsepower increased 2016 per cent (1). The figures give but a bare idea of the tremendously increased energy use which has resulted from and accompanied present day mechanization.

Coal is our chief source of energy, supplying 58 per cent of the world's needs. It is estimated that in the United States there is enough coal less than 3,000 feet below the surface to last us two thousand years at the present rate of consumption. Then too, present mining methods remove only 34 per cent of the available coal, leaving the rest behind because it is uneconomical to recover it. Improved mining methods and advancing prices should make it feasible to recover still larger amounts and to lengthen the time estimate.

One possible method of recovering more coal is now being tried by the Russians (2). Controlled amounts of waste oxygen and air are blown into burning drift coal and the resulting gases are drawn off through a ventilator shaft. They reported that 750,000–900,000 cubic feet of gas with approximately one-tenth the fuel value of natural gas were obtained daily while blowing, and about half that amount during subsequent non-blowing periods. This process mined and gasified coal not otherwise easily accessible.

A method of increasing our potential supply of coal is in the further application of fuel research. Already, this has increased the efficiency in burning fuels and resulted in great savings. Two examples will illustrate. It required 254 per cent more coal to produce one kilowatt hour of electricity in 1910 than it did in 1934. In this same year, the British steel industry used six million tons less coal than before, but produced the same amount of steel, a saving of $21,375,000 (3). If such savings are possible in two great industries, why not elsewhere? They are, but it requires expensive installations and large scale operation to effect these savings. This and reluctance to change, accounts for our present barbarous methods of burning coal.

Coal might be regarded as a raw material, great coking ovens erected near mines and the coal converted to coke and the by-products—

gas, ammonia and coal-tar chemicals. The coke could be used for the generation of electricity and both gas and electricity piped to the consuming centers. This would do away with atmospheric contamination and greatly improve efficiency. Of course, it would mean the construction of transmission cables and pipe lines, and no doubt the demise of certain railroad systems. A major change of this kind in the public utilities would probably mean a rather extensive social readjustment.

Petroleum is the second largest source of energy, furnishing about 23 per cent of the amount used in the United States. Here again, the mining methods are not very efficient for only 20 per cent is removed. The United States produced 910 million barrels of oil in 1934, about two-thirds of the world production (4). Thirteen billion barrels of underground oil were available by present methods in our country on January 1, 1935. At the present rate of consumption, barring new oil field discoveries, our supplies will be exhausted in fifteen years. However, this figure is low, for new fields are being found. The wells are deeper in many places and more expensive, yet oil is being discovered. As prices rise larger amounts will also be recovered from existing wells. Then too, there are vast quantities of oil known to exist in various places in a condition that makes economical recovery at present impossible. For example, a thirty-five foot limestone layer under Chicago contains seven million barrels per square mile (6). Then there are the oil sands, oil shales, etc., none of which are used to speak of at present.

Research work has made possible great savings in oil resources. The cracking process, which makes it possible to produce more gasoline from a quantity of petroleum, saved nine hundred million barrels of oil last year. The waste gases from storage tanks, cracking stills, etc., which were formerly wasted, are now used to make gasoline by a new polymerization process. It is estimated (7) that about one-fifth of all the gasoline used in America in 1934 could be made from natural gas in this way without curtailing the normal supply. This polymer gasoline has a high antiknock value, having octane ratings as high as one hundred.

Various methods are now in use for converting coal into gasoline and other liquid fuels. Germany, France and England are now operating commercial or semi-commercial plants for this purpose. Peat, lignite, cottonseed and alcohol have all been converted to gasoline and lubricating oils on a small scale but their use is uneconomical at present. However, the picture may change in the future. The petroleum supplies in our country are so vast that little interest has been aroused by these attempts, but those countries with limited supplies are vitally concerned.

Natural gas, like oil, is a wasting resource. Its use has increased considerably within the last few years and it now furnishes about 8 per cent of the world's energy. Indications are that our present supplies will last from 50–75 years. Here again, conservation and research can

increase the expected life of the supply. Removal of some of the higher hydrocarbons does not materially affect the usefulness of natural gas but does increase our gasoline supply, as mentioned above. When the gas supply runs low, we shall no doubt turn again to artificial gas from coal.

Water power is an everlasting source of energy. Intensive agriculture, with increased subsoil drainage may somewhat decrease the amount of water available for power but this decrease will be slight. Extensive development of water power sites has lagged behind because the natural power sites are frequently long distances from consuming centers and so require lengthy transmission lines, and the cost of constructing generating stations from water power is four to five times greater than for steam. Recently, however, the government has seen fit to undertake such construction on a large scale and we can expect a considerable increase in available energy from this source.

Power can be developed in other ways too. There are hot springs and geysers which could be used to supply heat and energy. Wells are known which are producing large quantities of water at 190°–230° F.

Volcanoes might someday be made to give part of their heat energy in a useful way. Abbott's solar power plant is a possibility for obtaining energy directly from the sun. The late Passamoquoddy Bay Tide water project offered possibilities from a new source. Then too, there is the wind, alcohol, warm ocean currents, and others—all of which may someday be made to contribute a portion of the needed energy.

All estimates that have been made as to how long the various resources will last are of doubtful accuracy for one very important factor has been omitted. This factor is man's ingenuity. Present day civilization has developed because man was capable of applying himself and overcoming obstacles of all kinds. It is quite unlikely that he will be daunted by certain natural resources playing out when he has modern scientific achievements to guide him and spur him on. The problem will be solved in some way and the world will continue to be a place where human beings live and work.

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Some Remarks on the Coal Testing Laboratory as Related to the Modern Coal Industry

O. W. Rees

Illinois State Geological Survey, Urbana, Illinois

Of the many interesting lines of specialized or applied analytical work, coal analysis is one which is becoming more and more important. This is evidenced by the fact that coal companies are now establishing laboratories for the analysis of their products. The increase in the number of such laboratories may be attributed to two major causes, the increase of coal preparation due to keen competition, which preparation requires control analyses, and to the growing tendency for the public, both industrial and domestic to buy fuel according to analytical specifications. Industry is coming to realize that errors in analytical results may be responsible for losses of thousands of dollars in the course of a year's time. In the case of one large company an error of approximately 1½ per cent in the calorific value of their coal resulted in penalties which amounted to about $18,000 in 8 months' time. Thus we see the importance of this line of applied analysis and the necessity of making such analyses as accurately as possible.

The sampling and analysis of coal is complicated by its nonhomogeneous character. Coal is made up of organic material which has undergone varying degrees of coalification. To this are added varying amounts of minerals such as calcite, pyrite, and clay minerals together with varying amounts of moisture. To satisfactorily sample and analyze such a heterogeneous material, therefore, offers its difficulties. Morrow and Proctor[1] have shown that individual lumps of coal ½—1 inch which were picked by hand from the same stream of coal varied in ash content from a minimum of about 1½ per cent to a maximum of about 66 per cent. This serves to emphasize the extreme danger in accepting an analysis of a single lump or a small quantity of coal as being representative of a larger lot of coal.

Sampling of coal must satisfy two requirements, the securing of a satisfactory gross sample and the preparation of this gross sample for analysis. In order that the gross sample shall be representative of the whole lot of the coal its size will vary with the nature of the product being sampled. For example, larger gross samples are necessary for large sized coals. Furthermore, different means of obtaining gross samples are necessary depending on whether face, car, or preparation

[1] "Variables in Coal Sampling" by J. B. Morrow and C. P. Proctor, A. I. M. E. Technical Publication No. 645, Table 3, page 11.

plant samples are to be taken. At present there are standard procedures outlined by the American Society for Testing Materials[2] for obtaining face and car samples, but as yet no standard methods for sampling prepared coals have been adopted. The increased amount of coal preparation has therefore created a great need today for standard methods of sampling these products.

Once a satisfactory gross sample is obtained the problem of crushing and quartering this down to a laboratory sample presents itself. This laboratory sample usually consists of about two pounds of ¼-inch coal which is further crushed and quartered in the laboratory to about 60 grams of -60 mesh coal for the actual analysis. Previous to this final grinding, however, the sample should be dried for some time, preferably overnight, in an oven through which a current of air is kept circulating at approximately 37° C. This drying brings about the loss of moisture which would readily be lost at room temperature and thus prevents troublesome loss of moisture in the later handling of the sample. Furthermore it provides a drier sample for the final grinding which sample can be readily ground without troublesome caking. This air dry loss is carefully recorded and is taken into account in the final results.

Coming now to the analysis proper we have a 60-gram sample of -60 mesh coal from which part of the moisture has been driven by air drying. The most common determinations made commercially are the proximate analysis including determinations for moisture, volatile matter, ash and fixed carbon by difference. To these may be added determinations for total sulfur, calorific value and ash softening temperature. For research studies and certain classification studies ultimate analyses may be made including determinations of carbon, hydrogen, nitrogen and oxygen. In some cases varieties of sulfur are determined including sulfate, pyritic and organic sulfur. Mineral carbon dioxide is sometimes determined and ash analyses are less frequently made. Certain physical tests are used in certain studies such as shatter tests, agglutinating tests, accelerated weathering tests, etc.

The majority of methods available for use in coal analyis are of the empirical type, that is, those in which all details such as time, temperature and kind and dimensions of apparatus are carefully specified. Since this is true it has been necessary to adopt standard procedures and to insist that all laboratories adhere closely to these standard methods in order that their results shall be comparable. The methods commonly in use are those adopted as standard by the American Society for Testing Materials[3]. In order to emphasize the necessity of close adherence to the conditions specified for these determinations let us consider briefly a few determinations. The determination of moisture in coal offers a good example of the absolute necessity of closely adhering to a standard procedure. It is possible to drive out different amounts

[2] Standard Method of Sampling Coal, A. S. T. M. Designation D 21-16.
[3] "Laboratory Sampling and Analysis of Coal and Coke." D 271-33 American Society for Testing Materials.

of moisture from coal by heating all the way from room temperature up to as high as 1000° C. It has therefore been necessary to set up an empirical procedure by which results for this determination may be duplicated. The moisture value is determined by heating a sample in a double walled oven whose temperature is regulated at 105° C by a boiling solution between the walls and through which oven air is passed at a rate to insure renewing the air two to four times per minute. Any deviation from these specifications will result in different values for moisture. In some cases ordinary drying ovens have been used for this determination. Such ovens do not fulfil the two most important specifications for such equipment, which are that the oven shall have a minimum of air space and shall be uniformly heated. An oven with square corners permits the formation of air pockets which are impossible to sweep properly, and heating units in the bottom of the oven do not effect uniform temperatures throughout.

The determination of volatile matter in coal is another very good example of the empirical nature of coal analysis. The amount of volatile matter lost upon heating a coal sample depends upon the temperature at which it is heated, the time for which it is heated, the type of equipment in which it is heated, etc. It is therefore necessary to very carefully adhere to the standard procedure which has been outlined for this determination.

Not only is it necessary to adhere carefully to standard procedures for the two determinations which have been cited above, but also it is true for other determinations in coal analysis. For instance, in the determination of ash softening temperature it is possible to vary the value obtained as much as 400°F. simply by varying the atmosphere in the furnace from reducing to oxidizing.

The requirements of control, marketing and classification analyses are somewhat different. Control analyses usually must be rapid, in many cases permitting sampling and analysis of many samples each day. Marketing analyses should be more accurate but not so complete as classification analyses where accuracy and completeness are essential. In all cases where possible standard equipment and procedures should be carefully adhered to. In cases where it is necessary to use rapid procedures the relation of results so obtained to results obtained by standard procedures should be determined.

We have shown briefly some of the difficulties which the coal analyst encounters. One must therefore realize the extreme importance of proper sampling, careful standardization, close adherence to standard procedures and acquisition of good technique in such a laboratory. And by no means has the last word been written in coal analysis. Contrary to the idea of some that there is no analytical research left to be done, there is a great need in coal analysis as well as in other specialized lines for new methods and for simplification of existing procedures to eliminate errors as much as possible.

Acid Catalysis in Liquid Ammonia

Charles Slobutsky and L. F. Audrieth
University of Illinois, Urbana, Illinois

It has definitely been shown that liquid ammonia possesses unusual properties as a solvent for many inorganic and organic compounds. Like water, it is the parent substance of a system of acids, bases and salts. When dissolved in liquid ammonia, ammonium salts have been shown to behave as acids. Liquid ammonia also acts directly upon many substances to produce solvolytic effects and such reactions are termed "ammonolytic" reactions. Just as phosphorus trichloride is hydrolyzed by water (Equation 1), so it may also be ammonolyzed by ammonia to give the corresponding ammono acid (2).

1. $PCl_3 + 3H_2O \rightarrow P(OH)_3 + 3HCl$
2. $PCl_3 + 5NH_3 \rightarrow P(NH)(NH_2) + 3NH_4Cl$

Many hydrolytic reactions are catalyzed in aqueous solution by acids, or bases. Thus, the inversion of cane sugar is catalyzed by acids and the velocity of the reaction is a function of the concentration of the hydrogen ion. This reaction has been used for the determination of the strength of acids in aqueous solution. Esters also undergo hydrolysis and, in some cases, such reactions have been markedly catalyzed by the hydrogen ion, or in terms of the modern Brönsted concept of acidity, by the solvated proton. It was therefore to be expected that the rate of ammonolysis of esters in liquid ammonia would be accelerated by the presence of ammonium salts.

Preliminary experimental runs indicated that ethyl malonate ammonolyzed at a sufficiently slow rate at 0° to permit of its more extended investigation. Parallel equations, (3) and (4), show the effect of water and ammonia, respectively, upon ethyl malonate.

3. $CH_2(COOC_2H_5)_2 + 2H_2O \rightarrow CH_2(COOH)_2 + 2C_2H_5OH$
4. $CH_2(COOC_2H_5)_2 + 2NH_3 \rightarrow CH_2(CONH_2)_2 + 2C_2H_5OH$

Weighed samples of ethyl malonate and ammonium chloride were placed in tubes which were cooled in a solid carbon dioxide-acetone bath. A definite volume of liquid ammonia was then introduced and the tubes sealed off and immersed in an ice bath. When the contents had reached a temperature of 0° C. the tubes were shaken and the initial reaction time specified as such. Tubes were removed from the thermostat at varying time intervals, cooled, opened and emptied into filter flasks. The ammonia was allowed to evaporate, the residue washed with ether to remove unchanged ester and the product weighed to determine the yield of malonamide.

The preliminary results of this investigation may be summarized as follows:

(1) The ammonolysis of the pure malonic ester is an autocatalytic reaction, since both of the products, malonamide and ethanol, behave as acids in liquid ammonia. Addition of either of these substances to the initial reaction mixture greatly speeds up the rate of formation of the amide.

(2) The rate of formation of amide is tremendously accelerated by the addition of ammonium chloride. The yield of amide at the end of a ten hour interval is a linear function of the concentration of the catalyst.

(3) Equivalent concentrations of various ammonium salts exert approximately the same catalytic effect.

(4) Neutral salts, such as NaCl, NaBr and NaI, also markedly accelerate the conversion of ester into amide.

Demonstration of Cold Light

Michael Sveda and L. F. Audrieth
University of Illinois, Urbana, Illinois

Many chemical reactions take place with the evolution of heat and light, but only a comparatively small number are known where radiant energy alone is emitted. Most cases of chemiluminescence involve either the use of rare and difficultly obtainable chemicals, or are not sufficiently intense to be suitable for classroom or lecture table demonstration.

The availability of 3-aminophthalhydrazide on the market (1) and the brilliance of and ease of production of chemiluminescent effects by its oxidation in alkaline solutions make the demonstration of cold light a relatively simple matter. If carried out carefully, the oxidation of "luminol" produces sufficient light in a darkened room to make the operator distinctly visible and capable of being photographed. Directions for producing this effect follow.

Dissolve 0.5 g. of 3-aminophthalhydrazide and 15 g. of sodium hydroxide in 5 l. of water contained in a 6-l. Florence flask. Then add 20 cc. of 3 per cent hydrogen peroxide. Gradually introduce small crystals of potassium ferricyanide, $K_3Fe(CN)_6$ and swirl the contents of the flask. As each crystal strikes the surface of the solution, it will appear to glow, and as the oxidant dissolves a greenish-blue light will be emitted from the contents of the flask. The light intensity can be regulated by adding varying quantities of ferricyanide.

Another striking demonstration is effected in the following manner. Prepare a solution of 0.5 g. luminol and 15 g. of sodium hydroxide in 500 cc. of water (Solution A). An equal volume of a saturated solution of potassium ferricyanide containing 60 cc. of 3 per cent hydrogen peroxide is next prepared (Solution B). Immerse a piece of cloth in solution A, remove it and squeeze out the excess of liquid. Then pour some of solution B on the cloth. It will glow brilliantly. If the cloth is then pressed the excess liquid will fall from it like glowing drops of molten metal.

For further information and demonstrations reference is made to an extended discussion of the subject of chemiluminescence by Huntress, Stanley and Parker (2).

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The Effects on Corn and Wheat Starch Gels Produced by Pretreating the Starches With Freezing or With Chemical Reagents

Sybil Woodruff and Majel M. MacMasters

University of Illinois Agricultural Experiment Station, Urbana, Illinois

A property of starch which makes it useful in food technology is its ability to swell in hot water and to set to a gel on cooling. This capacity, however, is influenced by various factors as has been demonstrated with both corn and wheat starches. Reid Yellow Dent corn or Champion White Pearl corn were sources of starch used in these studies, as well as Fulhio wheat which had been milled especially for certain Experiment Station projects. Suspensions containing five per cent starch by weight were heated to temperatures ranging from 70° to 95° C. and the character of the molded gels was noted after cooling.

GEL FORMATION BY CORN AND WHEAT STARCHES

Effect of freezing on cornstarch.—Corn grown in 1935 yielded its starch from the ground grain somewhat less easily than did 1934 corn. This was thought to be due to physical differences in the kernels of the two growing seasons. This modification of kernel was slightly less pronounced in corn which had been subjected for 24 hours to a temperature of –18° to –20° F. at a time when the moisture content of the kernels was 27 to 32 per cent. Gels of starch taken from 1935 corn, much of which was frosted before completely matured, did not leave the mold clean as was the usual case in 1934 with cornstarch gelatinized at 95° C. This denoted a different manner of holding the water in the gels. Freezing the corn did not noticeably alter the ability of its starch to form a gel, however.

Effect of sulfur dioxide treatment on cornstarch.—The usual factory practice of steeping corn for many hours in water saturated with sulfur dioxide was found so to alter the starch that a gel was not obtained unless the suspension was heated to a temperature of about 95° C. Such was the case with both commercially manufactured cornstarch and that made in the laboratory following the steeping of the corn in sulfurous acid. On the other hand, starch obtained from the same lot of corn, but with the sulfur dioxide treatment omitted, gave a well-formed gel after being heated to only 80° C. The same effect of sulfur dioxide

on starch was demonstrated by treating cornstarch, not corn, with sulfurous acid solution.

Effect of bleaching treatment on wheat starch.—The commercial practice of so-called bleaching which is applied to wheat flour is somewhat comparable to the sulfur dioxide treatment used in making cornstarch. This chemical treatment is valued as much for its improvement of baking qualities as it is for removing the natural yellow tinge of the flour. Wheat flours bleached by five different methods were found to show no measurable difference in gel forming capacity.

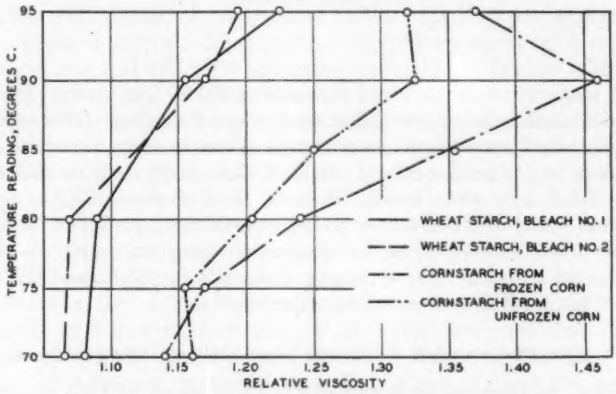

Fig. 1.—Variation of viscosity with temperature.

Effect of salts and sugar on corn and wheat starches.—Sodium chloride was shown to reduce the gel forming capacity of both kinds of starch, though more in the case of wheat starch than in the case of corn starch. The starch was first allowed to stand for two hours in 1.43 M sodium chloride, then water was added to bring the concentration of starch to a 5 per cent suspension which was gelatinized as usual. The final dilution was approximately 0.4 M with respect to sodium chloride. The resulting gels were gray and slightly less firm. Similar treatment with 5 M sodium chloride (approximately 1.7 M on dilution) caused considerably weaker gels to be formed by cornstarch and completely inhibited formation of gels by wheat starch, even on gelatinization at 95° C. Treatment with 0.43 M potassium citrate failed to produce any noticeable effect other than a graying of the gels. Sucrose completely inhibited gelation when 60 grams of it were added to 100 grams of either corn or wheat starch suspensions. This agrees with earlier results reported by Woodruff and Nicoli.[1] Ten grams of sucrose did not visibly change the gel though it was somewhat less firm.

[1] Woodruff, S., and Nicoli, L., Cereal Chem. *8*, 243 (1931).

VISCOSITY OF STARCH SUSPENSIONS

Viscosity has been used more commonly than gel formation as an index of degree of swelling of starch. Measurements of viscosity were made in the Stormer viscometer, employing suspensions containing 2 per cent starch. The pastes were first gelatinized in flasks, then transferred to the viscometer cup and maintained at the temperature of gelatinization during reading of viscosity.

Starches of frozen and unfrozen corn varied widely and irregularly in viscosity at different temperatures. Unrecorded data showed at times lower viscosity in the starch from frozen than from unfrozen corn. Graphs of two samples of wheat starches bleached by different methods are given as being typical of all results obtained with this starch (Fig. 1). The viscosity of corn starch suspensions was in every case greater than that of wheat starch and was also more affected by added chemicals. Sodium chloride treatment, similar to that used in studying effects on gelation, gave slight differences from normal viscosities, but these were not uniform in character. Potassium citrate or sucrose used in the amounts given in the table increased viscosity more regularly. Small amounts of sucrose increased viscosity greatly, large amounts to a smaller extent.

EFFECT OF CHEMICALS ON RELATIVE VISCOSITY

Chemical added	Concentration of solution added	Relative viscosity at 80°C.	
		Corn starch	Wheat starch
None		1.32	1.21
K-citrate	0.04 M	1.31	1.21
K-citrate	0.08 M	1.36	1.25
Sucrose	10 gm.*	1.42*	1.30†
Sucrose	60 gm.*	1.26*	1.19†

* This amount was added to 100 gm. of starch suspension.
† Corrected for viscosity of sucrose solution.

Putting Thrills Into Laboratory Experiments

Everett S. Anderson

Quincy Senior High School, Quincy, Illinois

ABSTRACT

Solution of Unknowns.—Numbered vials containing unknowns are handed out. Coded numbers are used so that the student can be informed of the success of his work at the time of report. The use of coded numbers enables the instructor to hand out a subsequent unknown with one or more of the same ions contained in the previous unknown in case of failure to detect these ions. Findings cannot be reported until vial has been turned in. A student may work as many unknowns as he can in a given period. The competition is keen and the satisfaction great from having solved a large number successfully.

Electroplating.—Silver, chromium, copper (alkaline cyanide), and nickel plating solutions are provided in four liter beakers arranged with buss bar, so that articles to be plated can be hooked on without having to make other electrical contact. Students bring buckles, paper weights, metal hair pins, metal horn mouthpieces to be plated.

Preparation of Ink.—The formula for the Government Standard Writing Ink is used. In a portion of the ink prepared the soluble blue is omitted. The use of this portion shows the oxidation of the ferrous gallo-tannate to the ferric state. Students are urged to make use of the ink they have prepared.

Preparation of Soap.—Sodium soap is prepared from cottonseed oil. This soap is moulded into cakes in aluminum milk test pans or dissolved in alcohol, to make a liquid soap. It is used in all laboratory cleaning requiring the use of soap.

Preparation of Edible Jelly.—100 ml. of water, 1 g. pectin, 0.5 g. tartaric acid, and 60 g. cane sugar are boiled until the temperature of the mixture reaches 104° C. When the mixture cools it gives a good grade of edible jelly without flavor. A grapelike flavor can be added by putting about ten drops of a one per cent solution of methyl anthranilate in pure alcohol into the mixture before cooking.

The Position of Organic Chemistry in a General Chemistry Course

Julius J. Gouza

Edwardsville High School, Edwardsville, Illinois

Organic chemistry is very often confusing and uninteresting to beginning students, and their attitude may be reasonably considered justifiable. I am now speaking of the organic chemistry as it is presented to our high school and college students taking an introductory course in general chemistry. True, the student is introduced to carbon compounds in these courses but it is the impression that this is done in such a fashion as to leave the student with the idea that organic chemistry is "advanced," and very difficult to absorb. Sufficient organic chemistry should be introduced to round out the beginner's point of view. Organic chemistry should be of more general interest than the material ordinarily included in beginning courses.

One of the principal purposes of teaching chemistry is to have the student appreciate Chemistry's contribution to the services of man. In what field of chemistry has the greatest advancement been made? "Organic chemistry, that is, the chemistry of the carbon compounds, has taken a development far overshadowing inorganic chemistry, or the chemistry of mineral substances. Chemists have prepared or know how to prepare hundreds of thousands of such 'organic compounds' few of which occur in the natural World."

The teacher of today has access to many teaching tools such as projection lanterns, sound motion pictures, demonstration models, blackboards, samples, and references. The most common of these is the textbook, which is largely responsible for the methods and content that is taught in chemistry. General chemistry books are beginning to include more and more organic chemistry that is of interest to the student. The first texts included only a chapter on carbon and its compounds which meant carbon dioxide and carbon monoxide, but today they include several, with a wider range of reactions, methods, and processes. The ideal situation would probably be to present a broad view of the entire field of organic chemistry, which would mean including hydrocarbons, saturated and unsaturated, alcohols, halides, organic acids, esters, ethers, aldehydes, and ketones. In presenting this material no one group can be over emphasized or stressed because of the lack of time. The aliphatic and aromatic compounds should be treated together, however most of the time will be spent with the aliphatic com-

pounds. By use of models and simple organic reactions a coherent picture may be presented. Time should be devoted to the proper nomenclature of organic compounds, then long dangling formulas will not be a terror to the students. However, students will still be confused by trade names of commercial products.

Once the foundation is laid, the practical connection between it and the student's life may best be shown by motion pictures or lantern slides, showing the process of manufacture and the apparent natural sources of products that he uses constantly. A few of the carbon products that the student consumes, wears, handles, and buys may be listed under the following heads: clothing, petroleum products, plastics, fuel gases, sugars, alcohols, rubber, fats, and foods. Besides making the material practical, realism may be added by taking the student through a chemical plant such as a coke plant or an oil refinery.

If the student takes no more chemistry than is offered in a general course, he will have a brief and broad view of the entire field, and if he pursues additional organic chemistry he will have a fair background upon which to build.

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Photography as a High School and College Course

J. H. Sammis

Peoria High School, Peoria, Illinois

In spite of the fact that many of the critics of public education are raising a cry that our curricula are too full of fads and frills there are a few persons who have the temerity to propose a new addition to the already long list of subjects offered in our secondary and higher institutions of learning. That addition is the subject of photography. In a few isolated places the subject is even now being taught, probably due to the enthusiasm of some pioneer soul and the farsightedness of an administrator or two, but the subject is certainly not yet looked upon as a standard course in most schools.

Ten years ago photography was in a state of development that was not far enough advanced to allow it much consideration as a subject. In the last ten years advances have been made that have apparently escaped the notice of the average layman and educator. No longer is it necessary to buy expensive lighting units requiring bulbs of great cost; we now have the inexpensive photoflood and photoflash bulbs. Films are so much faster and finer grained (when such film is chosen) and chromatically corrected that it is now possible for the rankest amateur to do year-round work. Chemical developers are so superior to some of the older ones that tremendous enlargements are now possible without the former grainy results, and the developers today are less toxic and longer lasting. Cameras are no cheaper, to be sure, but in the last five years improvements in cameras and accessories have been so startling as to leave even the seasoned camera enthusiast gasping.

Why should we teach photography? The answers are manifold. From a consideration of the commercial importance of photography one can easily see that there is justification for teaching it on that score. We teach free hand drawing in many of our schools. There are more people earning their livings at photography than there are at drawing. Furthermore, there are more people taking pictures for the sheer fun of it than there are people amusing themselves by sketching. We hold no brief against drawing and feel that there is a distinct need for it in our schools, but we feel that larger numbers of people could be attracted into a study of and appreciation for the graphic arts through photography than through drawing. That photography may today be considered an established art is seldom contested.

Those of us who are engaged in some form of educational work are continually being told by other educators that it is imperative that we prepare the oncoming generations of young people for intelligent and

profitable use of leisure time. If we are really serious in our statement and acceptance of such teaching, then here is a subject made to order.

Photography appeals to those scientifically inclined and helps to prepare them for other scientific pursuits, since photography so ably assists the sciences. Think for a moment what the following suggest: micrography, telephotography, crime detection, x-ray, spectographs, photocells, photo-timing devices. Anyone contemplating becoming a teacher, architect, doctor, engineer, lecturer, traveller, gardener, artist, scientist, policeman, journalist, publisher, printer, or parent (just to mention a few) could conceivably be of greater service to society and himself for knowing something of photography.

Photography appeals to both sexes equally well. Some of our greatest photographers today are women. Anyone with a critical eye and who looks for the photographer's name when he sees a good picture will recognize such names as Tony von Horn, Margaret Bourke-White, Christine Fletcher, Dorothea Lange, Tony Frissell and Dorothy Wilding.

Photography appeals to those mechanically inclined. There are almost limitless accessories and gadgets that one can construct for himself such as enlargers, lighting units, camera stands, trays, print washers, printing boxes, backgrounds, and copying stands.

Photography appeals to those artistically inclined. There are many people with the urge to create something pictorial but who lack the necessary muscular control and coordination to draw or paint who find in photography the necessary outlet for their emotions. Color blind people are actually fortunate in monochrome work because the frosted glass image in the camera does not mislead them by beautiful color that will subsequently be lost in the picture.

Photography appeals to the traveller or one who contemplates travelling because it offers him an opportunity to capture much of the charm of the things he sees but may never see again. Few of the box camera snapshooters ever approach the fine results obtained by one who has had training or experience.

In photography we find a subject well correlated to many of our other school subjects. Applications of physics, chemistry, mathematics, and art are all obvious.

If photography is ever to become a part of the curricula of our schools it will be through the enthusiasm and initiative of the teachers. Since so much of the technical end of photography is chemical the chemistry teacher will probably have to carry the brunt of the load. As for student acceptance of the subject there should be no fear. In the few instances where it has been tried the students have flocked to the course. It is one of those subjects that can be made difficult enough for the good student to get his teeth into and easy enough for the weaker ones to profit by. At present America leads the world in photography and there is little reason why we should not lead the world in photographic education.

Presentation, Correlation and Demonstration in Laboratory Work

Carl E. Schilz

Lincoln College, Lincoln, Illinois

Observation in several schools over a period of seven or eight years shows that after many decades of advance in chemical science there are two kinds of teachers in the laboratory classes of our schools and colleges, the good and the bad. The purpose of this paper is to help those who have the progress of their students at heart but have only a hazy idea of the various roles that an instructor must play in conducting a laboratory section successfully. Let us take an example that will illustrate two methods of attack, namely, the glass bending skill.

The opening session of the laboratory class usually consists of a group demonstration by the instructor of the seemingly simple operations of cutting and bending glass tubing, followed by a short practice of these arts by the students. Then five or more weeks later the teacher notices several students assembling a gas generator with tubing bends that are neither neat nor serviceable. These students may be left to struggle alone, referred to the opening exercise and told to review it, cheated of a chance to learn by the instructor who quickly bends the tubing for them, or they may each be given an individual demonstration with all the details carefully and slowly explained, each student repeating the process several times under the personal supervision of the teacher who coaches the points at which trouble is occurring until the skill is mastered.

This painstaking and time consuming process of scrutinizing the skills of each student and then patiently correcting all faulty maneuvers is the real purpose of placing an instructor in the laboratory of a beginning course in science. The method of individual demonstration should be applied to such procedures as filtration, washing, decantation, and lighting burners with only one match. (R. E. Horton in Sixth Yearbook of Department of Superintendence of New York City, page 351, lists 108 such skills that a student should acquire.) All of this means that the teacher himself must be a good technician; perhaps he will need to spend several long evenings perfecting himself, and perfection it must be for the students are quick to sense a lack of skill or confidence.

Only thus can neatness and accuracy be instilled into a class, and not until all these manipulative skills have become automatic habits can the student fix his attention on the chemical principles and relations that we wish him to become familiar with or do any thinking of an

analytical or constructive nature. It is absolutely necessary that he have both the skills and the understanding familiarity with the principles if he is to progress in the elementary or succeeding courses. The procedures may be shown to him by group demonstrations but in many cases individual instruction must follow.

Another type of group demonstration with an entirely different objective is the performance of a series of tests on a large number of materials of the same type. In such a case the students should have made the same test on several common materials until they are familiar with all the details of the manipulation. Then they can concentrate on observing, recording, and interpreting the results when the teacher runs rapidly through a large number of the tests. This procedure applies the test quickly and cheaply to a larger field than could be afforded from the standpoints of either time or cost if done individually. By covering a wide field we impress more clearly that the law is really general in its application, also we have a greater chance of hitting upon some application that is of interest to a given student. Certainly we show the tremendous extent of the field of chemistry in the world around us.

A third type of demonstration that is very useful may be called the cooperative demonstration. As an example, after having the class make the standard test for free alkali on three soaps, chosen to show the extreme cases, each student is asked to bring a small sample of his favorite soap to the laboratory. A check list is made on the blackboard to eliminate duplicates and enlarge the list of samples. It is also explained that for a satisfactory comparison test, water, which might produce a basic reaction through hydrolysis, is a better solvent to use than alcohol. They are told to dissolve about one gram in twenty ml. of water and add four drops of phenolphthalien, label the sample and place it in a test tube rack provided on the side shelf. The samples are then divided into three classes, good, bad, and medium, as determined by the depth of color. It is interesting to include some of the washing powders and chip soaps.

Here in a few minutes of cooperative work is built a demonstration of ten to twenty or more samples that would involve that many times as much work for each student if performed individually, a saving of as much as 400 times the work for a class of twenty students. Each instructor will find other cases where this method will bring an excellent survey of problems to a satisfactory conclusion.

Summarizing briefly, I have attempted to show that there is a need for four types of demonstration in the laboratory, the two types of group demonstrations by the instructor, the individual demonstration by the instructor, and the cooperative demonstration by the class, which combines the thrill and pride of intimate knowledge gained through individual work with the time and expense saving factors of group work. In addition we also teach the student the advantages obtained by pooling knowledge, a fact vital to our great industrial research departments.

The Place of Projects in High School Chemistry

M. E. Woodworth
Pittsfield, Illinois

A perfect educational process should develop in the boy and girl all the desirable traits which we wish to find in their mental and moral makeup when they are grown. It is impossible to find any one process to meet this demand so that we must resort to a variety of methods in education. One process that has been overlooked more than any other in the past is the use of projects.

The application of this method to science, which is an outcome of the Herbartian school, has been used only sparingly until recently. Widespread increase in its use in this State was encouraged by this academy when it began to sponsor a project contest in the Junior Section. The adoption of this policy was no doubt brought about by the excellent showing a few schools made in the first contest of this sort to be held, which was sponsored by the Illinois State Association of Chemistry Teachers seven years ago at a meeting of this association in Macomb. During this widespread increase many difficulties have been incurred in the application of this method probably due to the small amount of material that is at hand from which the teachers may get their information.

Sometimes the term "project" is misused by being applied too widely to situations that are not projects but only problems. A project is not merely a situation that may be solved by purely mental solution but it requires additional knowledge, understanding, and skill. It is in these last necessities that a great amount of the project's usefulness is founded. I can find no better reason for its use than the encouragement it offers a student in finding and developing these traits while working with a situation that instills into him an interest greater than can be stimulated by any other educational process. In addition to these outstanding achievements, the project method at its best may be credited with the development of more definite concentration of thinking, a greater effort in the use of the subject matter in problem solving and fact finding along with a development of the usage of facts as well as a higher standard of ideals and attitudes.

No educational method is free from errors. Probably one of the greatest handicaps that the project method has to overcome is the fact that so many teachers will allow it to degenerate into a series of poorly

written reports taken from articles or books. Probably this is the reason why projects are often times disregarded in the teaching of science. Certainly projects are not reports culled from magazines and encyclopedias and neither may they be imposed, for as such the spice is lost and with it a great deal of their real worth. Another thing that discourages teachers a great many times in the use of projects is the realization that this method is not easily taught. It demands a great deal of planning, supervision, and encouragement, all of which will demand from the teacher much time and energy as well as resourcefulness.

Since teaching this method is not easy a great many mistakes and failures will attend its use if not handled properly, because students are not able to carry on unaided the problematical work which is demanded. Therefore I must point out that although the project has a definite place in the teaching of chemistry it cannot be classified as chemical education itself.

When introducing projects into Chemistry the first question that arises in the teacher's mind is—"when shall it be taught, how much time shall be allotted to it, and what relation must it bear to the rest of the Chemistry course. These questions cannot be satisfactorily answered with one answer for all schools or situations but must be governed by the characteristics of each class that is to participate in this type of work. However, I might offer some suggestions that I have discovered through the use of this method the past several years. First of all I find that the mere suggestion that some time during the year the members of the class will have an opportunity to work on projects of their own will stimulate an interest within each student in Chemistry from the very first day of the term. It is seldom that I find a student who does not care to originate, plan, execute, and report on a project that he may call his own. Sometimes, however, this does occur and in such a case another kind of work should be provided for the student. This makes more work for the teacher but is necessary, for if the other students received the impression that their projects were forced upon them their interest would die and with it a great many of the valuable benefits. During the time I have carried on projects I have invariably found that they should not be introduced early in the school year since practically each project demands some technique that the new Chemistry student has not yet acquired. Neither can it be expected that he will get the greatest understanding or knowledge from his project until he has attained a background by the use of other educational processes for several months. Projects have done my students more good when they were introduced into the laboratory from the first to the middle of the second semester.

The statement that they are introduced into the laboratory may raise the question as to whether they should be carried on during the regular laboratory time, after school, or at home. To this I reply that the

project method is an accepted educational method, therefore why should it not have a place in the school today together with the other educational methods and processes if it is not allowed to overshadow them.

In Watkin's experiment with controlling classes in Chemistry doing project and nonproject work, the two groups stood about equal by pure factual testing but it must be remembered that a great many of the good points such as resourcefulness, initiative, and interest that we know are developed to a high extent in projects can not be measured by such tests. Neither are they necessarily bounded by the four walls of the class room but may reach to the home community and often farther, working towards ends in which the student can see immediate worth.

PAPERS IN GEOGRAPHY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

Of the sixteen papers on the program of the Geography Section meeting, only ten are here represented. The other six were as follows:

Human Geography in Relation to the Zonation of Vegetation in the San Francisco Mountain Region, by H. O. Lathrop, Illinois State Normal University, Normal.

Gardening in Fairbanks, Alaska, by Edna M. Gueffroy, Illinois State Normal University, Normal.

Answer to the Article Entitled, "Geography the Forgotten High School Subject," by Clare Symonds, Quincy High School, Quincy.

Population Pressure in Puerto Rico, by Wm. H. Haas, Northwestern University, Evanston.

Bloomington Under the Geographic Microscope, by Margaret Means, Bloomington High School, Bloomington.

A Study of Results in Geography Teaching, by Lina Webb, Benton High School, Benton.

The meeting was well attended.

H. O. Lathrop, 608 Normal Avenue, Normal, Illinois, was elected chairman of the Geography Section for the 1937 meeting.

(Signed) FLEMIN W. COX, *Chairman*

Exceptional Weather of Recent Years

Harold B. Ward

Northwestern University, Evanston, Illinois

Weather rules humanity to an extraordinary extent. A rhythm of climate is essential for man to achieve a high degree of civilization. Alternate periods of high and low temperatures or dry and wet weather produce a rhythm of climate. In recent years, however, the people of the United States have been treated to such exceptional weather conditions that the rhythmic succession has been disturbed with a magnitude far beyond the wildest forecasts ever conceived.

The year 1933 was much warmer and drier than a normal year. Only three preceding years of record in northern Illinois were warmer but during the summer of 1934 more local temperature records were broken than in any previous year and the absolute maximum for Chicago, 104.8° F., was established on July 24, 1934. The most outstanding feature of 1934, however, was the widespread severe drought. The precipitation in Chicago, 22.78 inches, was .56 of an inch lower than that of the previous driest year, 1930. The year 1935 brought weather that spelled disaster in many parts of the country and for the United States as a whole averaged 1.8° cooler than 1934. The winter of 1935-36 is so recently past that its severity is fresh in the minds of all observers except those of the southwest states where the temperature was normal or slightly above.

Tornadoes, hurricanes, and violent storms of all types are exceptional weather phenomena; they occur with unexpected force, and, unless they are tropical storms, cannot be accurately forecast. In 1933 the tornadoes—197 of them—a number rarely exceeded, were characterized by the U. S. Weather Bureau as plentiful, short-lived, and frightfully fatal. During that year 21 tropical storms, the largest number in 46 years of record, struck the area charted by the Weather Bureau. During 1934 there were few tornadoes and no very intense hurricane reached the coast of the United States, but in 1935, 179 tornadoes were reported and five tropical disturbances, each of full hurricane intensity, were reported in waters adjacent to the United States. Three of these hurricanes struck southern Florida with devastating violence, one was accompanied by the lowest sea-level barometric pressure ever recorded in the western hemisphere (26.35 inches) and two followed erratic unprecedented tracks. The hurricane during the first week of November, 1935, was not only one of erratic movement but also the first of record

to develop hurricane intensity at so late a date in Florida. Early in April, 1936, a series of extratropical tornadoes of exceptional severity devastated many sections of the southern states.

Other exceptional features of recent years have been the dust storms. At least five great dust storms spread over a considerable area of the United States and culminated in the most widespread of all, the storm of May 9 to 12, 1934. These resulted in part from the most extensive drought in the climatological history of the United States.

Exceptional low temperatures of the past winter have not only caused many people to believe that the winters are becoming more severe but that a recurrence of the glacial period is imminent. The nation was in the grip of the most bitter cold that had been experienced in a quarter of a century or more. The heating load for the three winter months in the Chicago area for the past 50 years has averaged 3,470 degree days. For the winter of 1935-36 it was 4,104 degree days.

Extraordinary changes in weather followed the severe winter. High winds and terrific blizzards followed by rapid melting produced floods in northeastern United States that surpassed all previous inundations. For the first time in history, the Ohio River on March 27, 1936, was above flood stage along its entire 981 miles from Pittsburgh to the Mississippi. So much water had fallen from the clouds and had flowed over the lands that no thought of another drought entered the minds of observers. But less than a month later, we learned that the deficiency in rainfall in several localities was sufficient to break the 1934 records and that an area of more than 30 million acres was in the grip of a severe spring drought.

Records continue to be broken; the warmest April 20 was experienced this year in Chicago when the mercury reached 82° at 3:08 P. M. and, because of a shift in the wind, tumbled to 55° in seven minutes.

Time does not permit a recital of the hundreds of minor eccentricities of the weather during recent years. Interest attaches to several problems presented by unprecedented conditions but perhaps the most common question is "can we conclude that the climate today is radically different than that of a century ago?" Meteorologists are not agreed as to the remote causes of the extraordinary weather of recent years but the immediate causes are known and they do not differ except for those that are the results of the changing environment from the causes of extraordinary weather conditions in past decades. A search of the records reveals that in all years unusual weather may occur locally and that certain years have been outstandingly warm or cold, wet or dry. Much more research is needed to solve all the problems but in the light of present knowledge one is forced to conclude that our weather extremes and great departures are the normal type of weather for the interior of this country and that abnormalities have occurred in the past and may be expected in the future.

Geographic Aspects of the Fruit Industry of Illinois

Ralph S. Harris

Westport Senior High School, Kansas City, Missouri

Apples are the most common of the orchard fruits and are grown in every county in the state. Commercial production, however, is limited to the southern part of the state.

We may roughly classify the commercial apple sections of Illinois as the Central Western, the South Central, and the Southern Districts.

The Central Western District centers in Calhoun County, with lesser plantings in Jersey, Greene, Pike, and Adams counties. This section produces the late ripening varieties and is the leading producing district of the state. Taking the single year 1929, Illinois produced 3,025,895 bushels, which was a short crop inasmuch as the five year period 1928-32 showed an average of 5,019,000 bushels. The Central Western District produced a little over 35 per cent of the 1929 crop and Calhoun County alone produced 21 per cent of the total crop of the state. This area has pushed forward in the number of bearing trees from 1920 to 1930. Calhoun leads the procession, for her number of trees of bearing age has more than doubled during the ten year period. With her good climate, rolling topography, and deep, rich loess soil, she has ideal conditions for the growing of apples. A recent test, the results of which were announced in August, 1935, stated that the Department of Agriculture found that Calhoun County apples contained more sugar, better flavor, and higher color than any grown elsewhere in the United States. The test was made on fruit produced in every section of the country. A new highway bridge across the river at Hardin and the railroad extension to East Hardin have broadened her market. Formerly, the apples were shipped to St. Louis by boat.

The South Central District is composed of Cumberland, Jasper, Richland, Clay, and Marion Counties, together with parts of Crawford and Effingham counties. It may be said to be the second most important commercial area in the state, but the industry in this region is now distinctly on the decline. The number of trees of bearing age in 1930, in the seven counties named in this region, was less than 15 per cent of the number in 1900. This area was, in fact, the first important apple producing center of Illinois. Throughout the territory there are no large highly developed apple sections and both the early and winter varieties are grown. Some adverse factors are encountered here, such as spring frosts which cause irregularity in the yield, an impervious subsoil which comes near the surface making the land absolutely un-

suited for orchards, and level land which makes drainage a serious problem.

The Southern District includes Union and Johnson counties, together with parts of Jackson and Williamson. The region is one of the leading early apple sections of the United States. Fruit moving late in June or in early July has the advantage of a fairly open market to the west, north, and east of this district. The number of bearing trees declined in this area between 1900 and 1924, but during the period 1920 to 1930 the total number of trees, both bearing and non-bearing has increased a little over 27 per cent, the greatest increase being in Union and Johnson counties. Thus, we can see that this district, together with the Central Western District has increased rapidly from 1920 to 1930. However, in contrast to the ideal Calhoun centered district, the soil here is of poor physical texture and low in fertility. In some places there is an outcrop of stone. The topography and character of the soil presents an erosion problem. The apples in this section blossom early and there is often considerable damage from spring frosts which check the normal development of the fruit. On the other hand the section has some advantages over others. Early apple movement, good transportation facilities throughout the distributing territory, and abundance of cheap labor and land, coupled with the fact that few crops other than apples and peaches can be profitably produced on this land, are all tending to favor this territory as one of the most important centers for early apple production in the United States.

Considering the average production of apples for the five year period 1928-32, Illinois ranked tenth among the states.

Peaches are the second most important of the orchard fruits of Illinois, but their production is more limited than that of the apple due to the great hazard of winter killing of the fruit buds and often the trees. Low temperatures in the spring months, during bloom, is another great hazard. In Illinois the production of peaches fluctuate greatly with the climatic conditions. There were no peaches in 1918 and 1930 and less than a fourth of a crop in 1919, 1921, 1932, and 1933. The five year period, 1928-32, showed an average production of 1,889,200 bushels, during which time Illinois ranked next to the important states of California, Georgia, and North Carolina.

In spite of the great chances taken, because of weather conditions, commercial orchardists in the extreme south and southeastern part of Illinois are willing to gamble on getting a crop as the state's peaches go on the market about three weeks ahead of the Michigan fruit. Too, the Elberta crop in Illinois fits fairly well into a period when there is a decided dropping off following the end of peach shipments from Georgia.

The total number of peach trees reported in Illinois in 1930 was 4,027,456, nearly three-fourths of which were trees of bearing age. The

number of trees of bearing age declined a little over 64 per cent between 1910 and 1920, with the largest decline in the small farm orchards. However, the total number of trees increased from 1,851,037 in 1920 to 4,139,100 in 1925.

The southern Illinois peach region is a comparatively recent development, the production being rather small in 1924. A survey made in 1925 indicated that 77 per cent of all the peach trees in the commercial orchards of Illinois had been set in 1920 or later. A slight decline in the total number of trees was noted from 1925 to 1930, while only 25 per cent of the trees were of non-bearing age in 1930 as compared with 45 per cent in 1920. The total number of trees in Union, Johnson, Pulaski, and Jackson counties was two and a half times as large as in 1920.

Commercial peach production in Illinois is limited to the Southwestern Section centering in Union, Johnson, Pulaski, and Jackson counties, and the South Central Section centering in Marion and Jefferson counties.

Taking the single crop year 1929, which was almost a million bushels above the average of the five year period, 1928-32, the Southwestern Section is by far the most outstanding production center. It produced 40 per cent of the state's crop in 1929, with Union—the outstanding peach producing county—producing 22 per cent of the state's total, and alone, almost as much as the South Central District. This section has a rolling topography that gives good soil and air drainage.

In the South Central Section there is greater risk of frost damage than in the Southwestern Section as the surface there is fairly flat. Crop failures in this region are common. Marion County had more peach trees in 1900 than any other county in the state, however, the number declined until 1920 when thousands of new trees were set.

The pear is the third most important of the deciduous tree fruits of Illinois. The Kieffer is the principal variety grown, while the more recent plantings include the Garber. However, neither variety is of high quality, consequently, they do not command the price of the better varieties from the Pacific Coast States. Fire blight, a disease, is the limiting factor in the production of the high quality varieties in Illinois.

In 1930, Marion County had nearly one third of the state's pear trees of bearing age. In 1929, she produced nearly one third of the total crop of the state. The 1929 crop, however, was above the five year 1928-32 average which was 445,800 bushels—the 1930 Federal Census figures showing 538,667 bushels for Illinois.

The pear is more resistant to frosts and winter than any other Illinois fruit tree. It will stand wet feet better than any other fruit tree that we grow in Illinois. Since it is quite level in Marion County, making drainage a problem, the pear is not so handicapped with excess moisture as other deciduous fruit trees.

The total number of trees in the state declined quite rapidly from 1910 to 1920 and increased following the war, but declined 21 per cent between 1925 and 1930.

In grapes, Illinois ranks higher than is generally known. Taking the single year, 1929 Federal Census figures, she ranked tenth in grape production among the states. The number of grape vines, according to Federal Census figures, showed her ranking eleventh in 1930.

There is an intensive commercial planting in Hancock County in the Nauvoo district. This county is by far the leader and in 1929 produced a little over 28 per cent of the grapes of Illinois and in 1930 had a little over 26 per cent of the state's bearing and non-bearing vines. Practically the entire crop from the Nauvoo district is ferried across the Mississippi River to Montrose, Iowa, and from there taken by rail to states north and northwest.

Peoria and Madison counties rank second and third respectively in the total number of vines in the state.

The Nauvoo district in Hancock County has ideal conditions with a west exposure on the Mississippi. Here the air and water drainage are good and the soil is moderately fertile. Since the grape vine will not stand wet feet, the water drainage is very important. There are favorable sites and soils in other parts of the state, especially in the southern third and along the Mississippi River in the western part.

In 1900 there were nearly as many grape vines in Pulaski as in Hancock County, but the number in the southern county declined rapidly from 1900 to 1910. In 1900 in the entire state, there were 3,008,888 vines of bearing age and that number declined to 1,750,332 in 1930.

The strawberry is the most commonly grown of all the small fruits of Illinois. They are grown in all counties and in most of the counties there are some commercial plantings to supply nearby towns. The larger commercial plantings are found in the southern part of the state. The acreage of this fruit varies greatly from year to year, due to the short period that individual plantings are allowed to fruit. However, within the past few years a new district in Edgar County has been pushing forward.

The strawberry thrives in widely different soils and climates, but seems well adapted to the good sites of southern Illinois that provide good air and water drainage. Pulaski County produced 13 per cent of all the state's strawberries in 1929.

In the southern part of the state the strawberries are not far from the Illinois Central Railroad which provides good fast transportation for this highly perishable fruit. On short hauls, the trucks are taking their share of the business away from the railroads[1].

[1] Acknowledgement is given to Professors A. S. Colby, R. S. Marsh, and R. L. McMunn, of the Department of Pomology of the University of Illinois, for their suggestions in the preparation of this manuscript.

Geographic Aspects of Meat Production in Illinois

Emilie Huck

Community High School, New Baden, Illinois

The purpose of this paper is to show (1) where the meat animals are produced in Illinois, (2) what the present tendencies are in production, and (3) the reasons for such distribution.

The production of hogs in Illinois is far more important than the combined production of sheep and beef-cattle (Fig. 1). This is partly accounted for by the fact that much of the farm land in Illinois is too expensive for pasture land, consequently more hogs are produced than sheep and beef-cattle, which require more pasture.[1] Mutton and beef also require more feed to produce a unit of human food than does pork.[2]

DISTRIBUTION

There are comparatively few hogs in the southern one-third and eastern one-half of Illinois, but numbers in the western one-third are as dense as anywhere in the United States. This location of hog raising in Illinois is surprising to those not well acquainted with the state as they ordinarily expect large numbers of hogs to be found in the heavy grain producing prairie sections of central and eastern Illinois.

The geographic distribution of swine in the United States is primarily determined by the distribution of corn.[3] There are, however, several interesting discrepancies between the distribution of swine and corn. Illinois shows one of those discrepancies.

The greatest center of corn production is in east central Illinois, yet comparatively few swine are raised there, principally because of the high price of corn and the small amount of clover grown. The farm price of corn in east central Illinois averages a few cents per bushel higher than in western Illinois, owing in part to the nearness to the Chicago market where a large amount of corn is made into glucose, shipped to other parts of the United States, or exported to other countries. The freight rates to Chicago on corn from points in western Illinois are enough higher than from nearby points in east central Illinois to make the feeding of corn to hogs and the shipment of the hogs to Chicago more profitable than the shipment of corn. Pork is worth several times as much per pound as corn, furthermore it represents only about one-fifth of the weight of corn, and hence can bear better the cost of trans-

[1] Rusk, H. P. *Rept. Ill. Farmers' Inst.*, Vol. 20, 1915, p. 112.
[2] Baker, O. E. *Graphic Summary of Am. Agr.* Misc. Pub. 105, U. S. D. A., p. 96.
[3] Finch, V. C., and Baker, O. E., *Geog. of the World's Agr.* U. S. D. A., p. 130.

portation. In western Illinois also more clover and other kinds of hay are grown, owing in part to soil and topographic adaptation. These combined with corn make a more complete feed than corn alone.

The distribution of beef-cattle and sheep in Illinois is more uniform than that of hogs, but, again the concentration is greater in the northwest and west than in the south, and for the same reason as for swine.

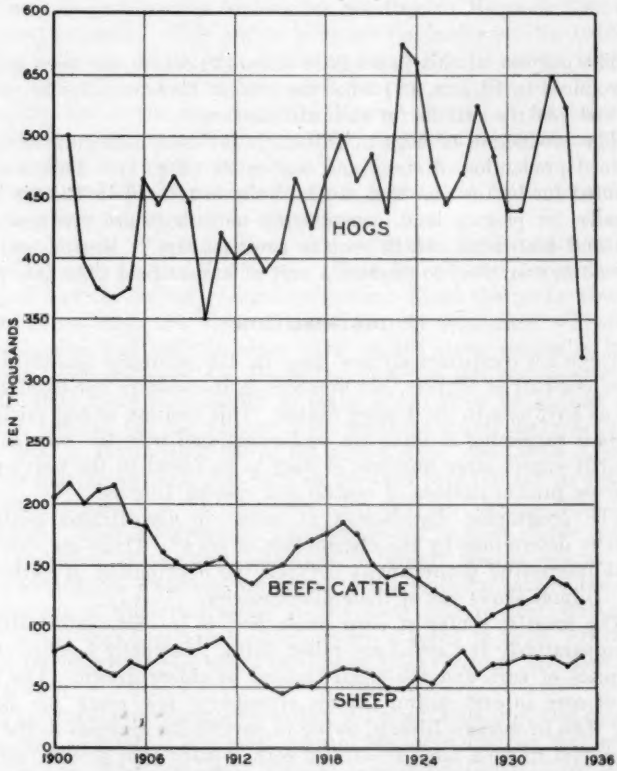

Fig. 1.—Graph showing production of hogs, beef-cattle, and sheep in Illinois.

TRENDS

The general trend of hog production in Illinois from 1900 to 1935 has been upward (Fig. 1). There are sudden and sharp fluctuations in this period, but each high mark exceeded the previous high, with but one exception, the post-war high of 1923. The 1933 peak, however, was only

4 per cent below the 1923 peak. From 1931 to 1933 hog population increased rapidly until the Hog Control Program of the federal government made a drastic curtailment in production, the 1935 crop being more than 50 per cent below the 1933 crop, and the lowest since 1910.

The number of beef-cattle in the state has steadily declined since 1904 (Fig. 1). The increase during the war period was only a temporary condition, for the downward trend set in again in 1920, and production reached its lowest mark in 1928. Since then there has been a slight upward rally until 1934 and 1935 when numbers were greatly reduced by the severe drought of 1933 and the consequent feed shortage. The general decline in production in the early part of the century is due to a change in the complexion of the cattle industry,[4] a change from what was formerly, practically a breeding and rearing proposition to one that is almost a purely finishing proposition. The post-war decline in number is due to an improvement in the livestock, quality replacing quantity. Science has improved the animal industry so that there is greater productivity per animal.[5] The recent upward trend in both the hog and beef-cattle industry is probably due to the fact that the use of the tractor and the automobile has caused a decline since the World War in the number of horses and mules, with the resultant release of a large number of acres of crops to feed to other farm animals.[6]

The sheep industry in Illinois has declined since 1900. Diversified farming, the growth of dairy interests around large urban centers, and the growth of grain farming have pushed sheep off to more remote grazing grounds.[7] The sheep industry is an extensive type of agriculture, and tends to disappear from regions of dense population and expensive land. Internal parasites, predatory dogs, and the method of farm tenantry in Illinois further discouraged the sheep industry.[8] The increase in the sheep industry since 1928 is due to the marked increase in wool prices. Prices advanced sharply in 1933 to a point well above the pre-war price. Sheep numbers in most of the important sheep-producing countries are now declining, following five years of expansion. Drought in 1933 in several countries of the southern hemisphere foreshadows a further decline. World prices as well as the prices in the United States advanced.[9] The increased prices of sheep products plus the low price of grain warranted the increased production in sheep, whereas production of both hog and beef-cattle decreased.

[4] Rusk, H. P., *Rept. Illinois Farmers' Inst.* Vol. 20, 1915, p. 112.
[5] Wallace, Henry A., *Yrbk. of Agr.* 1934, U. S. D. A., p. 26.
[6] Baker, O. E., *Graphic Summary of Am. Agr.* Misc. Pub. 105, U. S. D. A., p. 1.
[7] Finch, V. C., and Baker, O. E., *Geog. of World's Agr.* U. S. D. A., p. 135.
[8] Coffey, W. E., *Rept. Ill. Farmers' Inst.* Vol. 20, 1915, p. 117.
[9] Bean, Louis H., and Chew, Arthur P., *Yrbk. of Agr.*, 1934, U. S. D. A., p. 121.

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6. *Yearbooks of Agriculture,* U. S. D. A.

An Atlas of the Geography of Illinois

W. H. Voskuil

State Geological Survey, Urbana, Illinois

ABSTRACT

I have been asked to present to the Geography Section of the Academy a brief statement of a proposed Atlas of Illinois Geography, the purpose of the Atlas, the nature of its contents, the progress of the work, and the probable time of completion.

This Atlas is being prepared by Professor Haas of Northwestern University, Professor Blanchard of the University of Illinois, and myself in order to meet the needs of public school and high school teachers for a source of reference and supplementary material to the standard text books on the Geography of Illinois. The Atlas will consist mainly of maps and economic charts with a brief description of each chart. It will be composed of eight sections, as follows: Physical Geography, Climate, Agriculture and Forestry, Minerals, Industry, Transportation, Population, and a Special Chicago Section.

Collaborators on the Atlas, in addition to Professors Haas and Blanchard are Dr. Voskuil, Professor Cox, Professor Ward of Northwestern University and graduate students in their departments.

Up to the present time the sections on climate, agriculture, minerals, and portions of the Chicago Section are in progress or nearly completed. Publication of the Atlas should be sometime this coming year.

The nature of the illustration materials of the Atlas can best be grasped from an examination of some of the completed charts. (Several maps and charts that will appear in the Agriculture and Minerals sections were shown with a brief discussion of each.)

The Relation of Dams and Reservoirs to the Water Supply of Southwestern California

Richard H. Jahns

Northwestern University, Evanston, Illinois

The utter dependence of a populated semi-arid region on an adequate water supply, though a self-evident concept, is nevertheless one which entails many unforeseen complications. The inhabitant of a humid region, accustomed to drawing his water in any desired quantity from nearby lakes and rivers, finds it difficult indeed to conceive of the problems faced by communities in southwestern California. The Los Angeles Basin alone, an area surrounded on three sides by high mountain ranges and on the fourth by the Pacific Ocean, contains over fifty per cent of the people in the state, while but seven tenths of one per cent of the state's water occurs there.

Since this South Coastal Plain, or Los Angeles Basin, is a center of population, industry, and agriculture, its water supply problem, as compared with that of neighboring districts, is unusually severe. Embracing an area of nearly 3,000 square miles, some 2,200 of which are suitable for agricultural or residential development, it is drained by the Los Angeles, San Gabriel, and Santa Ana rivers and their tributaries. There are approximately ninety cities and urban communities in the district, and nearly all the remaining land is used in the raising of citrus fruits, nuts, grapes, grains, and other agricultural products. In the region south of Los Angeles industrial development is pronounced, embracing steel mills, oil fields, and factories of various kinds. Increasing demand of these enterprises for water is naturally expected.

The improved area has the form of a gently sloping, undulatory plain, extending roughly twenty-five miles from sea-level to an elevation of nearly a thousand feet at the base of the mountains. Normal yearly rainfall on this plain is fifteen inches, though seasonal variations are common. The mountains, some of which have altitudes of ten thousand feet, receive more nearly twice that amount. Since the climate of the region is of the Mediterranean type, most of the precipitation occurs during the winter, when it is least needed for agricultural purposes. For this reason, irrigation of crops during the dry summer months is essential. Furthermore, though evenly spread through the winter and spring, the individual falls of rain are often torrential in character, their waters swelling streams to many times their normal size and quickly discharging across the plains into the ocean as waste.

The site of the Pueblo of Los Angeles was chosen largely because of the available water in the nearby Los Angeles River. This was in 1781. It is significant that but twenty years later a dam was built across the

river, diverting water for irrigation and to a lesser extent storing it for use during unusually dry seasons. For 133 years the Los Angeles River continued as the sole source of water, until a series of dry years and a rapidly increasing population forced engineers to look elsewhere for water. It was not until late in the nineteenth century that realization came to most people concerning the true nature of this river, however. It has since been stated that southern California streams "flow upside down," and recognition of this fact was one of the greatest single steps in the growing knowledge of water resources in the region. The water in these streams actually flows through and is filtered by the highly porous gravels beneath the surface. Thus, the water obtained from wells in Los Angeles was of adequate amount and superior purity.

Applications of this new concept soon came into use. It was soon obvious why the smaller streams, perennial in the mountains, disappeared beneath the surface upon reaching the floor of the Los Angeles Basin. The question immediately arose as to how this water could be saved. The answer was the construction of subsurface dams on the outwash plains of a few such streams, their effect being to bar the underground passage of the water and force it to the surface, where it could be used. The more important type of dam, however, was not man made at all, but a product of geologic activity. The mountains surrounding the plains area have been uplifted along a series of faults in comparatively recent geologic time, and have constantly contributed coarse gravels to the areas along their base. These gravels themselves have been offset by faulting or by the initial irregularities on the bedrock "basement" in such a way that individual subsurface basins were developed. In a sense, these are reservoirs formed by natural damming of the water-bearing gravels, and have been the major source of water for Los Angeles, Pasadena, and neighboring cities for many years. In addition, actual artesian areas nearer the coast were discovered.

But these new sources were foolishly and wastefully exploited. Artesian areas decreased in size from an original 375 square miles to a few dozens of square miles by 1914, while other gravel basins were so alarmingly overdrawn that ground water levels fell as much as seventy feet. Springs dried up and the waters of even the large streams sank into the gravels and disappeared. Los Angeles, realizing that stringency of water would seriously affect its growth, settled its metropolitan problem by building an aqueduct from the Owens River watershed, on the east slopes of the Sierra Nevada Mountains, 250 miles across the Mojave Desert southwestward into the Los Angeles Basin. Capable of supplying the needs of two million people, the Owens River aqueduct has five major dams and reservoirs along its length, constructed for purposes of storage, flow regulation, and power plant use. Without these structures, an aqueduct of such length would not be sufficiently flexible for practicability. At the present time, a forty-seven mile extension is being built to tap the waters of Mono Lake, thus making available enough

water to fill the aqueduct to its maximum mean capacity of approximately 300,000 acre feet per year. Two large reservoir dams and several smaller stream diversion dams are involved in this project.

Other communities met the problem in similar fashion. Though the canyons in the mountains are narrow and offer few good reservoir sites because of their steep profiles, dams were nevertheless built. The function of these structures, which are found in nearly all canyons of any importance, is twofold: first, to divert water for domestic use of the cities lying in the basin below; and second, to arrest the rapid progress of flood waters during and immediately following heavy rainstorms, allowing these waters to escape later, when they can be used. Check dams of this sort are becoming important, especially since many forest fires on the mountain slopes have increased the runoff speed.

The water supply problems of this region are by no means solved at the present time. Estimates for 1934 showed an actual overdraft on ground waters in the Los Angeles Basin amounting to nearly 166,000 acre feet per year. The larger cities of the district are meeting this situation by constructing an aqueduct from the Colorado River that will be capable of delivering over one million acre feet of water per year. Large dams are being built across the Colorado and San Gabriel rivers, the former to divert the water and the latter to form a storage reservoir. Six other dams and reservoirs are contemplated.

The agricultural districts, however, cannot afford to use such transported water for irrigation; hence they must look to more immediate sources. Studies of ground water conditions in the basin have revealed that overdraft is due to avoidable waste, rather than to lack of supply, since estimates show an excess of 400,000 acre feet over present demands. Conservation of waste waters is being carried out along several lines, the most important of which is the use of check dams in the control of floods. The flood waters are later released, as mentioned before, and spread over the gravels in the basin below, replenishing the ground water supply. Reclamation of sewage waters will eventually contribute some 100,000 acre feet of water annually, while the importance of rain falling in the basin proper is being recognized.

Similar conditions obtain in other areas of southwestern California, though a scattered population makes the situation less acute. Nevertheless, there is hardly a stream course that doesn't have at least one dam along its length, and all indications point to continued erection of more and more of these structures as the demand for water increases. Some 130 years have elapsed since the construction of that first dam across the Los Angeles River, a period during which but a single process (though with many variations) has been used to obtain water. This is simply the prevention of runoff from reaching the sea by diverting it for human uses, and as long as human uses continue to exist in southwestern California, dams and reservoirs must be an integral and essential factor.

Some Problems of Egyptian Agriculture

W. O. Blanchard

University of Illinois, Urbana, Illinois

While Egypt is the "gift of the Nile," like many free offerings there have been certain "strings" attached. True, in its natural state the great silt burdened river with its regular rise and fall has been able to transform its narrow flood plain from a desert into a garden. But the oasis was *small* and it was productive *only* during the season of natural flooding so that the output of food became inadequate for a growing population.

Attempts to increase production have been repeatedly made, especially during the past century. They had two major aims (1) to extend the productive area, and (2) to increase the yield per acre. Dams and barrages, canals and dikes, were built to both increase the water supply, to raise the water onto higher land, and to equalize the seasonal flow.

In general, then, the problems today, as in the past, center about the balance of *land and water* on the one hand, and of *population*, on the other. Both these factors are susceptible of a considerable degree of control. However, thus far attention has been centered only upon increasing the food supply; little or no effort has been made to restrict the birth rate. The latter has, in fact, far outrun the means of subsistence. In the past 50 years it is estimated that the cultivable soil has been doubled, but the population has multiplied four-fold. As a result there are now crowded onto that narrow flood plain some 14,000,000 people, the vast majority of whom are illiterate, miserably poor, hopelessly in debt, almost naked and half starved. A cotton rag, a bowl of corn mush and a few dung cakes (for fuel)—constitute the sole reward for the daily toil of millions. One hesitates to say they are "making a living"; rather, they are "ekeing out a bare existence."

How closely the population presses upon the food supply may be appreciated by computing the size of the individual holdings. For many years, the average number of acres per landowner has decreased until it is now less than 2½. But this average does not reveal the real situation. That is still worse. Forty per cent of all the cultivated land is in the hands of only one per cent of the proprietors. As a consequence over ⅔ of all of the land owners average less than one acre each! Some of the holdings are unbelievably small—less than 3 feet in width.

It is obvious, then, that of the various problems confronting Egyptian agriculture, none is more serious, none more pressing, than that of the education of the masses. While Egypt is the seat of one of the oldest civilizations, today, over 90 per cent of the peasants are illiterate. Their farming methods are essentially the same as in the days of the Pharoahs. Above all, this education should include an understanding of the necessity for birth control, of sanitation and of hygiene. Egypt has the highest death rate of any country for which we have statistics, but its birth rate is likewise one of the highest.

The second problem, or group of problems, has to do with increasing the quantity and the variety of agricultural crops. What may, reasonable be expected in this direction?

It is estimated that of the potentially productive area in 1935—some 7,100,000 acres—only 5,500,000 acres were actually cultivated. The difference includes:

(1) 200,000 acres of waste in Upper Egypt now not used, to be irrigated.

(2) 1,400,000 acres of brackish swampland on the Mediterranean border of the Delta, requiring both drainage (by pumping) and irrigation.

In addition, of the land already cultivated, some 1,200,000 acres produces but a single crop annually, because of a lack of water during the summer. This is to receive perennial or year-round irrigation.

All of the above proposals presuppose *more* water and in addition a *better regulation* of the supply. More dams and barrages, pumps for delta drainage, a second heightening of the Aswan Dam together with added canals are part of the program. Some of these projects will be in the Sudan (English) and others within the border of Ethiopia and will involve cooperative agreements with those governments.

One unusual problem is that of the Sudd—a vast swamp of floating vegetation. Each year this material lodges in the channel of the White Nile. Here the river current is checked, evaporation is extremely large and there is a vast amount of water transpired by the vegetation. As a consequence, of the water entering the Sudd, only about ½ passes on to be available for irrigation. The most feasible solution of the difficulty seems to be to cut a new channel around the swamp and direct the river through this artificial canal.

One of the disquieting features of the food supply situation is the trend, apparent for many years, toward decreased acre-yields. Year-round cropping which has accompanied the institution of perennial irrigation, the deposit of the fertile silt back of the dams instead of over the fields, the general use of the animal manures for fuel instead of for fertilizer—all of these have made the problem of maintenance of soil fertility a difficult one. Other possible reasons for declining yields are being studied and further experimenting will be necessary before making recommendations for correcting this trend.

One further difficulty of Egyptian agriculture must needs be mentioned here, the need for crop *diversification.* Few countries are so economically dependent upon the production and export of a single commodity as is Egypt upon cotton. It is the all important, almost the only, money crop. Four-fifths of the country's export by value is represented by this staple. Thus, with all of their "eggs in one basket", price fluctuations of cotton brings prosperity or ruin to millions. Legal restriction of the maximum area which may be devoted to cotton has been the corrective used thus far.

All in all, it seems that the most important factor in the Egyptian environment is the Egyptian *farmer,* himself. No amount of engineering to increase production will permanently improve the economic status of the native as long as the great mass of people persist in breeding up to the extreme margin of subsistence. Every such increase in food supply in the past has been promptly followed by an increase in the number of mouths to be fed. Neglecting to recognize the ***human*** factor in the equation has simply resulted in a vicious circle and no progress.

Alaska-Yukon: Unique Adjustments, Yet Unsung

C. Clifton Aird

Morton Junior College, Cicero, Illinois

One likes to feel that he is a pioneer—that he is a discoverer. The Alaska-Yukon region today is one of the places where, in one summer one can see much that he has never heard of nor read about. One reads much of the midnight sun, the well developed airplane service, the intense cold, and the activities in this high-latitude land. But one does not read of the simple adjustments that have been made in this large sparsely populated region. One can read of the "largest number of airplanes per capita" but one does not read of such things as what happens to the five-gallon gasoline containers once they are emptied.

Since the airplanes serve all the region, gasoline must be cached at somewhat converging points along the elastic air lanes. It is in this manner that the containers get distributed throughout the land. They are rectangular—bright and shiny when new — always soft and easily smashed. They serve as water pails when the top is cut off, and a wire handle is added. If water must be carried far, a thin slab of wood floats as a cover to keep it from spilling. One sees these pails everywhere, in towns, villages and at lone cabins.

Other containers are cut apart and serve as shingles; some of the pieces are used as patches on boats; some serve to strengthen the skii that replace the summer's wheels on the airplanes that do not use pontoons; some strips are attached around the posts that support the cache. These stop small animals from getting into the winter's food. Basements of course, are practically unheard of in this land of frozen subsoil.

Other containers—with the top intact but with one side removed, become a dish-pan, a pan for cooking cereal for man or dog, or a pan that serves as a laundry tub. A home-made plunger with a stick and an empty condensed milk can complete the laundry equipment in this region of men—trappers, miners, wood-cutters.

Mention has been made of the frozen sub-soil. Only the upper 3–6 feet ever thaws. The frozen gold-bearing sands and gravels of old stream beds, must be thawed before they can be dredged. (The individual miner must be content to work the upper layers.) The thawing is done by forcing (through hose and pipe) cold water into the ground. It percolates and penetrates slowly—that which is beginning to thaw

this summer, will continue thawing the following winter, and will be the location of next summer's dredging. The cold of winter, then, cannot refreeze the thawing of one summer—or, the cold of one winter cannot re-freeze hard enough the freezing of many winters.

At Fairbanks, the bigger buildings (bank, federal building, the town or city hall, and school-house) are constructed of re-inforced concrete. The new buildings at the University of Alaska, some five miles out in the country from Fairbanks are also of concrete. There is no building stone near, and lumber is, of course, a fire hazard (especially in this town where the mains are kept empty until the alarm is sent in). The foundations for the Fairbanks buildings rest on or in the frozen depths. Small piles of brush are burned, the heat below thaws all the night, and the next day the partly frozen material is hacked out, until ever-frozen depths are reached. The four-story Federal Building is now four years old, and there are no cracks to indicate settling.

The smaller cabins which are typical of the region, seem about to disappear into the "mush". One has the feeling he is going into a hole or a den, for these rest on the surface or very shallow foundations. All buildings, whether cabin, school, hotel or trading post, have a hole or opening near the ceiling for ventilation. This vent may be round or square, may be closed with a rag or be slatted, may be purchased or be home made. The vent is necessitated by the need to allow the heated air which would normally gather near the ceiling to escape. If it did not escape, the roof would sweat, and the room would be damp, uncomfortable and unhealthy. With 67 degrees above inside, and that much (or more) below zero outside, much rime gathers outside the openings to festoon the building. Wood is the common fuel. Stoves are cast iron or made of the iron barrels that we associate with iron oil-barrels.

Another building adjustment (also related to the cold) is the well-like entry in all public buildings. The entry is a room a step or two lower than the main floor. On entering, one door is closed before the other is reached. Any cold admitted settles, or is caught in this "catch basin", and when the inner door is opened there is no (or little) draft.

Although the impression is gained that dog teams are unusual, there are many teams still used by Indian, Eskimo, trapper, freighter and, of course, the government has teams. The prospector rarely has a team, although he may have a dog or two for company and as pack animals. During the summer, the white man may find his team a nuisance. They must be kept tied, fed, and watered (a gasoline container cut in half supplies two water pans). If the owner wants to do some seasonal work with a dredge company, if he wants to go to the trading post on the river, if he wants to go "Outside", then he finds his winter's necessity a summer's nuisance. There are, however, individuals that make a business of boarding dogs for the summer. Their places are near some center such as at Fairbanks or at Dawson, or along the Yukon where

river transportation serves to connect a widely scattered population. Mention has been made that the government owns dogs. The Mounted Police of Yukon have no mounts, but use canoe, skii or snow-shoe, dog-team or airplane.

There are many other unique adjustments which the environment has influenced. There are the board-marked graves in a land lacking in stone. One cannot help but realize the scope that a gold rush reaches after reading from the markers the original home-land of the deceased. Paper flowers are plentiful, and they suggest the lack of flowers or the futility of placing them on the winter's grave. They do not suggest that the green-houses (now dilapitated) are filled with lettuce, radishes, cucumbers and tomatoes. There is the white beaded altar skin in the Episcopalian mission at Ft. Yukon. There is the soddy or *yertch* that is occupied by some young men attending the University of Alaska. There is the Experiment Farm there (University) which is crossing cattle with the musk-ox to develop a new high latitude dual purpose breed.

There are many adjustments not commented upon, many unobserved. At Sitka there is the new home for old men. One side faces the sea. It is for the sailor and fisherman. The other side faces the mountains. It is for the trapper and prospector. One looks in, the other looks out. There is, yet, much to be discovered.

Some Aspects of Geography of the Foochow Basin

Lin Kwan-te
Northwestern University, Evanston, Illinois

China, a densely populated country.—China is large in area but small in usable land. This means uneven distribution of population. Fully 83 per cent of population lives on 17 per cent of the land.[1]

The Foochow Basin, a unit in China.—The Foochow Basin, one of these densely peopled units has an area of about 150 square miles with about 700,000 people. Foochow City, the Capital of the Fukien Province alone has 322,725 people while numerous surrounding villages make up the rest. Thus the basin has a density of about 4,000 persons per square mile.

All usable land is every where under cultivation including terraced slopes and land on the mountain tops, in order to furnish the necessary food supplies. The basin with a little more than one per cent of the area of Rhode Island, the most densely populated state, has an equal population. It has been estimated that about 60 per cent of the total population is directly dependent on the land. Each person in the basin then is entitled to own only .14 of an acre of land.

Because of the density of population horizontal expansion in the area is limited while vertical growth to the mountain tops and down along river banks has been going on for years.

The character of the population and the life of the people in the Foochow Basin.—There are at least four groups of people classified according to the topography and occupation. The first is the city group including those living in the walled city and in the suburb, south of the city. These people are connected mostly with business, commerce, government and the professions. In the walled city, "the bee hive," is found the greatest density of population.

The second group lives in villages scattered throughout the basin. These villages lie close together and are separated by very regular fields. Commonly all the people in each village are descendants of the same family. Among these rural communities both men and women work on farms and do other heavy work. These women are nicknamed "Field Women." They are recognized by three large and sword-like silver ornaments which they wear in the coil of the hair at the back of the neck.

[1] Independent Critic, No. 3, Peiping, page 9, 1932.

The third group is the "Boat Population" including thousands of people making their homes in tiny house boats moored along the banks of the Min River. Both men and women are skillful sailors. Modern means of communication have replaced to a large degree, their labor. The competition is keen. Their frantic efforts to get passengers to cross the river bring them to the attention of every new arrival in Foochow.

Besides handling local river traffic some of them make a living by fishing, and some engage in bringing cargoes back and forth between Foochow and interior towns. The Min River on account of rapids becomes less navigable toward its head. The native junks or sampans of various sizes carrying twenty to sixty tons of goods are dragged up the river by means of long bamboo poles and by hemp cables pulled by the members of the boat family.

The fourth group is a mountain population. Some people build their little scattered rural communities on surrounding mountain tops and valleys. Farmers have terraced all possible mountain slopes. The chief occupations are farming and the cutting of wood for fuel. Both men and women carry the products of their co-operative labor with poles on their shoulders to the densely populated community at the foot of their mountain.

Habits of thrift and industry have their roots in the geographic conditions and are of long tradition. Children, rich or poor, are taught to value even a grain of rice. "Do not waste nature's gift" is a family slogan. Meals are carefully planned to avoid possible waste. The average cost of living relative to American standards is low. The cost of food for each person is around two to four dollars per month.

The large family or clan system of living together is a reflection of geographic conditions. It has been practiced as a means of living more economically and with better mutual aid. In the family there may be only a few people who earn the living for the entire family of several generations under one roof. The spirit of sharing is considered a virtue.

Geographic Setting.—The geographic make-up of the Foochow Basin has profoundly affected the lives of its inhabitants as described above. The region is surrounded by very steep granitic mountains towering up to 3,000 feet forming a natural and most magnificent and unique basin. On account of ocean and mountain barriers the people formerly enjoyed perfect isolation. Geographic isolation and absence of conflict resulted in a spirit of conservatism.

A profound effect of Foochow's geographic setting is also found in its dialect. The basin has its own dialect, unintelligible to the people beyond the limits of the basin. But this linguistic handicap has been overcome in some degree by the enforced adoption of the national language (or Manderin) in public meetings as well as in class rooms.

The Min River cuts through the basin approximately in an East-West direction. The periodic floods enrich the already fertile soil. For

many centuries the Min River served as the only means of communication between Foochow and the interior.

The climate is of the humid subtropical type. The mei-yu or moldy period together with fog occurs generally in March, April and May and has a very high humidity, so high that the moisture condenses on all cold objects. Human disposition is greatly affected by this unpleasant atmosphere.

Economic make-up of the Foochow Basin.—The tea trade forms the backbone of Foochow's economic make-up. In the most prosperous trade period tea represented 80 to 90 per cent of the total export. Tea and other trades together have suffered greatly on account of outside competition.

About 90 per cent of Foochow's exported commodities come from her hinterlands along the Min River valley. They include tea, timber, paper, bamboo and its products, and formerly camphor and tung oil and so forth. About 85 per cent of the imported goods are distributed in her hinterlands.[2]

Between the years 1871-1880 Foochow ranked third in the trade volume among seven leading trading centers in China. But between 1921-1929 Foochow was out of the list. The economic situation is becoming more critical. The trade situation has been very unstable.

Future of the basin and some of its problems.—Foochow is handicapped by mountainous topography which isolates her from favorable contact with the outside world. The Min River, the life line of communication, has a V-shaped valley with a narrow winding exit and is shallow in its upper river course. This limits the usefulness of the river.

Outlets of Foochow's commodities have rapidly been closed. Formosa, once Foochow's chief market, now exports into the Foochow Basin. England, once the chief tea customer, trades now with Ceylon and India. Smuggling of goods by Japanese into Foochow increases the seriousness of the situation.

The Chinese Government has laid a program for economic reconstruction. Many changes have been taking place which involve changes in the minds of many Chinese. There are forces pushing for modernization and there are forces retarding it. There is a constant conflict between the old and the new. Chinese are given a choice between modernization, and tradition and old heritage. They are given a choice between chopsticks and forks. All these changes will involve the changes of an entire philosophy of life.

Geography furnishes a skeleton, man must do the building. Better economic conditions mean greater buying power, world powers in turn share the benefits. This could only be attained by fair trade and better co-operation among nations.

[2] China Maritime Custom Report, Shanghai, 1861-1928.

Santa Marta, the Banana Port of South American

Rose Zeller

Eastern Illinois State Teachers College, Charleston, Illinois

Santa Marta, located in the northwest part of South America, is about 700 miles north of the equator and 2100 miles due south from New York.

The small harbor, which looks like a large ampitheatre, has an opening one and one half miles wide. The slopes are covered with thorn tree and cacti instead of the palm trees, so typical of the tropics. It extends in a northeast southwest direction, and is sheltered on the north and northeast, from the prevailing Northeast Trades, by a long rocky spur of the San Lorenzo Range. These almost bare hills jut out abruptly from the land and end in two islands. A beacon is placed on the larger island, while a beacon and a lighted buoy on the inner spur guide the pilots when ships are in that part of the harbor. Two buoys direct their course farther south.

In the inner harbor under the northern headlands, where the minimum depth alongside is 27 feet, two docks are built parallel with the shore. Each dock accommodates one ship. The long wharves enable cargo to be taken from all holds at the same time. The only mechanical handling equipment which the port possesses are the electric conveyors used for loading bananas. Ships use their own tackle for other cargo which they discharge or receive here. Cargo is handled by ships' slings directly to or from the freight cars. The exports are, in order named, bananas, coffee, hides and skins and dividivi. There are not port facilities for storage or for bunkering.

Santa Marta is built on the alluvial plain of the Manzanares River. The city may be divided into four sections; the center being the oldest. The narrow streets faced with low buildings, all lead to the cathedral.

The important market occupies the center of the business district. The railroad which diagonally cuts across the little city puts one section north of it. In this treeless area, most of the laborers, who work on the docks, live. In El Prado, in the south, the United Fruit Company has built attractive bungalows for its employees. Here in direct contrast to the north, grow many flowering bushes and trees.

Seaward of El Prado are the tall masts of the Wire Tropical Radio Telegraph Company. This wireless station gives communication with important Colombian cities and the outside world.

South of Santa Marta is the banana region. This region blocked out by the Sierra Nevada de Santa Marta Mountains on the east and the delta lands of the Magdalena River on the west, furnishes an ideal situa-

tion for banana plantations. The mountains give protection, from the Northeast Trades, to a broad sloping alluvial plain, and the melting snows and frequent rains of the upper slopes supply the water needed for irrigation. High temperatures vary but little and the region ranks high in the hours of sunshine.

The Santa Marta Railway begins at the docks and ends about 58 miles to the south. A ride over this road takes one through the cacti and thornybush covered hills, across the wide savana pastures, past little clusters of adobe or sheet-iron huts set in clearings in the tropical-scrub forest and into the banana region.

About three-fifths of the banana area belong to private Colombian planters but the United Fruit Company, which owns the rest, buys the fruit from the private planters, transports it to the docks and ships it with their own.

The banana plantations seem cut from the same pattern. Each has its master drainage ditch and its many canals. The fertile friable soil is a sandy loam, containing 30 per cent clay and 70 per cent sand.

The root-stalks are set in rows, the plants cultivated and three allowed to grow from each stalk. At the end of twelve to fourteen months the plantation is producing and continues to pay for about six or seven years. Each plant bears a stem of fruit, which weighs on an average, fifty pounds.

Plantations are divided into sections and the fruit in each section is cut once and in some seasons twice each week. The cutting gang consists of the man who selects the stems, the cutter, and the backer. "Thin" bunches are selected for shipments to Europe; "fuller" bunches for New York and New Orleans.

After the bunch has been selected, the cutter, using a long sharp-pointed pole, breaks the trunk of the banana plant and it bends over. The backer then catches the stem on his shoulder, the cutter severs it from the plant with his machete and the backer carries it to a cart, waiting in the nearest grass-covered lane in the section.

These carts carry the stems to the loading platforms or directly to trains on the sidings. At various times during the day the cars are assembled and sent in long trains to Santa Marta.

After the incoming cargo has been discharged and the holds cooled the bananas are loaded. This requires about twelve hours. The cars are run in on the docks; the fruit is carried from the cars past inspectors and placed in the canvas pockets of the conveyors which move to the holds of the ship.

In the holds men remove the stems from the conveyors and arrange them in the different compartments; two layers of standing stems, one horizontal. Fresh air, kept at a temperature of 56 degrees, is circulated through the compartments. Temperatures are taken every six hours.

Each year the United Fruit Company brings thousands of stems from the banana plantations in Santa Marta to the United States.

PAPERS IN GEOLOGY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The program for the Geology Section included nineteen papers, all but three of which are here represented. Those three were as follows:

Origin of Chert, by Charles H. Behre, Northwestern University, Evanston.

The Stratigraphy and Structure of the Mississippian System of the Quincy Region, by George E. Ekblaw, Illinois State Geological Survey, Urbana.

Subsurface Geology of the Quincy Region, by L. E. Workman, Illinois State Geological Survey, Urbana.

The meeting was well attended.

Mr. L. E. Workman, Illinois State Geological Survey, Urbana, Illinois, was elected chairman of the section for the 1937 meeting.

(Signed) HAROLD R. WANLESS, *Chairman*

The Classification of Illinois Coals Under the Operation of the Guffey Bill*

G. H. Cady

Illinois State Geological Survey, Urbana, Illinois

The Bituminous Coal Conservation Act of 1935, better known as the Guffey Bill, designed to stabilize the industry, is symbolic of a change that is taking place in the minds of the citizenship toward our solid mineral fuels. This change is revealed in the recognition given in the body of the bill to the fact that differences existing among coals affect their absolute value. The effect of the bill is to establish a schedule of prices which will reflect the actual differences among coals, thereby eliminating from any market those coals which, if equitably priced, would necessitate a mine price below the cost of production. With the bill in operation there would theoretically be no choice among the coals offered for sale at any market. All would be fairly graded with respect to actual value. Thus the bill states: "minimum prices . . . shall reflect the relative market values at points of delivery in each common consuming market area of the various kinds, qualities, and sizes of coal produced in the various districts."

Following the terms of the law it became necessary for each district board to establish these equitable prices at points of delivery for each variety of coal produced within the several mining districts in the different states. Serious difficulties faced many of these boards because of the absence of reliable data in regard to the coals over which they had jurisdiction, to say nothing of the absence of any reliable classification.

The paragraph in the bill relating to coordination of prices and regulations states that all minimum prices "shall be just and equitable and not unduly prejudicial or preferential." This statement should probably be regarded as the usual legal redundancy in explanation of the phrase "shall reflect . . . relatively market value." However, undoubtedly those who would be adversely affected by price rulings in accordance with relative market values would appeal for special consideration on the ground that such rulings were "unjust and prejudicial" with respect to their product under the previously existing competitive price conditions.

Price conditions at the time when the Guffey bill went into operation had generally been determined by boards operating under the authority of the National Industrial Recovery Act popularly designated

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NRA. These boards did little more than "freeze" existing prices previously built up through competitive practice and as determined by the judgment of the members of the board. It is said that factors such as the following actually determined prices but it is not known how their relative importance was evaluated:

Commercial analysis
Ash fusion temperature
Appearance
Physical structure and friability
Marketability
Degradation in transit
Storage qualities
Consumer preference
Plant performance
Effect on plant maintenance
Market and price listing.

We see that each board found itself instructed, on the one hand, to fix prices so that they should reflect relative market values, and, on the other hand, to avoid action likely to be assailed as "prejudicial" to previously existing advantages. Obviously the law, if carried literally into full effect, would constitute a serious infringement on the competitive marketing of coal as the system has been built up.

The boards turned to their task with vigor. The establishing of an equitable price scale required some basis of classification. Many states have so little public information on the classification of coal that the only possible method of evaluation was that used by the NRA boards, a classification by "the best judgment and experience of persons who have spent years in producing and marketing coal," thereby tending to perpetuate the *status quo*.

In Illinois a somewhat unusual condition existed because shortly before the Guffey bill was put into effect and the Bituminous Coal Producer's Board for District 10 (Illinois) was established the State Geological Survey published a classification of Illinois coal by rank in accordance with the tentative standards of the American Society for Testing Materials issued in September 1934. The classification was based upon evidence that had been accumulating for more than twenty years and was so thoroughly authenticated by time and experience that the neglect of such data by the Board was a remote possibility.

In this State, therefore, as in no other, the price-fixing board found it possible to take very literally the admonition of the law to establish prices "to reflect relative market value" at least to the extent that such prices could be fixed by rank, ash, and sulfur values. The board used the data supplied by the Survey as a basis for evaluation of the coals in the various districts, employing county averages weighted with respect to production. The value used for comparison was the "as received" value based upon rank, and the average ash values with heat of sulfur

eliminated. So far as coals were mined and prepared in essentially the same way this would give values essentially equitable for all sizes.

No other factors were used in evaluation, such as agglutination, ash-softening temperature, weathering characteristics, etc., because of the impossibility of placing definite evaluation on such factors with respect to all types of combustion devices.

This basis of evaluation was undoubtedly rational in character and based upon well substantiated evidence for Illinois coals. However, it is realized that the heat value of a coal is not the only basis for selection if imperfect combustion devices are used. There were therefore cogent arguments advanced against the strict application of the evaluation based upon calorific properties. To meet this objection the Board devised a scheme of adjusting the values based upon the calorific index so that they would agree more nearly with the prices previously set by the NRA authorities. That is, in the case of most coals 60 to 80 per cent of the price was determined by differences in calorific value and 20 to 40 per cent by previously established prices plus 15 cents. Although such a scheme to a considerable extent vitiated the effect of classification in accordance with actual and measurable differences it is considerable satisfaction to know that the standard method of classification was recognized and given consideration in classifying Illinois coals.

How was this classification applied to determine the price of coal to the purchasers (dealer or consumer)? First it was necessary to establish a basic price for Illinois coal. This was done by a study of mine costs and resulted as fixing $2.60 per ton for lump coal and $1.50 for screening—an average of $2.05.

These were the basic prices for southern Illinois coal since this coal was valued at 100 per cent. Therefore, $2.60 (or $1.50) plus average freight rate to a market area established the basic price for southern Illinois coals. From this value was then established the local price of coals from other producing districts on the basis of 60 per cent or 80 per cent scientific classification and 40 or 20 per cent NRA price + 15 cents. The freight rate to the particular mining district was then deducted, giving the mine price. By a system of averages standard differentials between districts were established such that in the large northwestern market area Belleville-Central Illinois coal would be priced at $1.95 and northeastern Illinois coals at $2.25 as compared with $2.60 for southern Illinois screenings.

For local markets within the coal field, mine prices were made by applying scientific and NRA ratings + 15 cents directly to the basic price of $2.60. Thus we have prices varying from $2.60 to $3.25. In some instances it is quite apparent "intangible factors" are more important than scientific classification in fixing mine prices.

For coal shipped to local consuming market compensation is made for difference in freight but definite minimum mine prices are established varying from $2.30 to $1.80.

After a satisfactory method of classifying Illinois coals had been accomplished, adjustment with other districts became necessary. Such adjustment has not been consumated. After numerous conferences, however, standards of classification for all coals were adopted, March 21, 1936 and the following rules were made:

In making classification of coals, all pertinent factors, including those set forth below, shall be given due consideration by the District Boards:

(1) Proximate analyses; namely, moisture, ash, volatile matter, fixed carbon and sulfur, B.t.u's and ash softening temperature, analysis of ash, and ultimate analysis of coal.

(2) Physical characteristics.

(3) Plant performance characteristics.

(4) Market history and sales experience.

Just what the members of District Board for District 10 will do in the way of conforming to this ruling is difficult to foretell. It can be safely stated that classification can be satisfactorily achieved using some of the items but is entirely impossible on the basis of others. It seems probable that the board will stand pat on the conclusions that have been obtained on the assumption that values are based on the only substantial data available.

Of considerable importance to coal geologists and other technicians interested in coal is the attention that the successful operation of the act will undoubtedly require in the field of scientific classification and empirical tests. Undoubtedly the technicians will devise more and more methods for measuring such characteristics of coal as have a definite application to use. Correlation of such empirical data in order to permit substantial generalizations will require more careful investigations of the immediate physical and chemical properties of coal whereby variations arising from differences in type and in rank may be more thoroughly understood. This act of Congress has given a tremendous impetus to coal geology that undoubtedly will be recognized in the schools and colleges as well as in technical laboratories.

The Separation and Concentration of Vitrain, Clarain, and Fusain in Illinois Coal*

C. C. Boley and L. C. McCabe

Illinois State Geological Survey, Urbana, Illinois

The ingredients composing the bands in Illinois coals are termed vitrain, clarain, fusain, and durain, each of which possesses distinctive physical and combustion characteristics. Variations in the relative proportions of these ingredients must therefore affect the usefulness of a coal for any given purpose. The Illinois State Geological Survey has undertaken a study of such variations. Summarized data relating to the screenings from one mine in Williamson county, operating in No. 6 coal, are presented herewith.

Before proceeding with an examination of the data, the nature and relative importance of the four ingredients might well be reviewed. The homogeneous, vitreous-appearing vitrain is characterized by low ash content and high as-received calorific value. When coked, it has great swelling power and yields a fragile, well-fused coke, evolving important amounts of by-products. Vitrain comprises about 46.0 per cent of the screenings investigated.

The non-homogeneous clarain is seen to be finely banded, with a bright silky lustre and blocky fracture. Due to its content of coalified remains from the more resistant parts of the coal-forming plants, its as-received ash content is higher than that of vitrain, and its calorific value is somewhat lower. Clarain is structurally stronger than vitrain, and hence tends to concentrate in the larger sizes. The data indicate 41.9 per cent present in the screening studied.

Coal commonly breaks along layers of the soft and friable fusain. Although this ingredient shows great variability in chemical composition, it has, in general, considerable ash and a high fuel ratio $\left(\frac{FC}{VM}\right)$. The latter factor together with its naturally fine size recommends it for pulverized fuel firing. Thiessen[1] has found 200-mesh dust from an Illinois dedusting plant to be very rich in fusain, indicating a possible source of supply. The screenings examined in this work contain about 2.4 per cent fusain.

* Published with the permission of the Chief, Illinois State Geological Survey.

Durain has been definitely noted in only four Illinois mines, appearing as a narrow band. Although it closely resembles bone coal, it may have a low ash content (3.7 per cent in one instance), a high percentage of volatile matter, and a low specific gravity. It forms a weak sandy coke and its ash fusion temperature is relatively high[2]. However, its extreme hardness causes it to remain in the lump coal, so that it appears in insignificant proportions in the screenings.

Details of the method employed in making the microscopic counts have been described elsewhere by McCabe[3].

Table I summarizes the results of the petrographic analyses in terms of standard coal sizes. A comparison of these data with a previous analysis[4] of a column cut from the coal face at this mine demonstrates that ordinary preparation processes appreciably affect the actual character of the coal. The relative toughness of the clarain causes it to be somewhat concentrated in the sizes larger than 1¼ inches, as is shown by the drop in percentage from the coal at the face to minus 1¼-inch screenings; while the more brittle vitrain has been more than doubled in the finer coal. Fusain and refuse matter likewise increase in the screenings. A study of the three common screening sizes indicates the trends of the ingredients with reduction in size. It is seen that vitrain, fusain, and refuse tend to increase, while the clarain content drops markedly.

Since most of the refuse material appears in the heavier gravity fractions, cleaning of the various sizes of coal at, for example, 1.50 specific gravity may be expected to reduce the refuse considerably. Table II presents data on dedusted screenings from which all sink at 1.50 has been removed. The refuse contents are all greatly lowered; and the minimum figure is reached not in the largest size, as was true for uncleaned coal, but at ⅜ inch x 48-mesh. Here, then, is a coal having an identical refuse content as the original face sample, 2.0 per cent, but with over two and one-half times the percentage of vitrain, double that of the fusain, and only about one-half that of the clarain. It would seem that we have produced a coal of greatly changed composition, which might be expected to form less ash on the grates and more by-products in the coke ovens.

It is thus apparent that coal preparation processes not only produce different sizes, together with a reduction in ash content, but they give us truly different coals which are composed of different proportions of the ingredients and which undoubtedly possess different combustion, coking, and hydrogenation properties. It is the aim of the State Geological Survey to study these changes by accurately determining the variations in the concentration of the ingredients in a number of typical Illinois coals. Combustion tests to correlate with the data on composition will then be undertaken. It is highly probable that we may some day produce concentrates of the ingredients, blending them as need be to produce coal of optimum composition for any specific use.

TABLE I—SIZED SCREENINGS FROM COAL NO. 6

	Vitrain	Clarain	Fusain	Refuse
	Per cent	*Per cent*	*Per cent*	*Per cent*
Face sample[4]	20.1	76.5	1.4	2.0
1¼ inch x 0—Screenings	46.0	41.9	2.4	9.7
1¼ inch x ¾ inch—Chestnut	42.4	49.5	1.7	6.4
¾ inch x ⅜ inch—Pea	47.5	43.2	1.5	7.8
⅜ inch x 0—Carbon	47.4	36.5	3.3	12.8

TABLE II.—COAL NO. 6 SCREENINGS DEDUSTED AND CLEANED AT 1.50 SPECIFIC GRAVITY

	Vitrain	Clarain	Fusain	Refuse
	Per cent	*Per cent*	*Per cent*	*Per cent*
1¼ inch x 48 mesh—Screenings	48.7	46.5	2.3	2.5
1¼ inch x ¾ inch—Chestnut	44.0	51.0	1.7	3.3
¾ inch x ⅜ inch—Pea	50.7	45.6	1.5	2.2
⅜ inch x 48 mesh—Carbon	51.2	43.6	3.2	2.0

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A Collecting Trip into the Jurassic of Southern Mexico in 1935

A. C. Noé

University of Chicago
Illinois State Geological Survey

I had hoped for some time to collect in the Lower and Middle Jurassic beds of the Mixteca Alta in the state of Oaxaca, Mexico. G. R. Wieland had been there in 1909, and later published his Flora liasica mexicana (Instituto de Geologia de Mexico, Bull. 31, 1916). During a visit to the Institute in 1934 I had an opportunity to examine Wieland's types, and was impressed by the fact that these fossils could shed a new light upon the history of gymnosperms. I arranged for an exploration trip during September, 1935, after having attended the sessions of the Seventh American Scientific Congress held in Mexico City that year.

I had the good fortune of having Dr. F. K. G. Müllerried assigned as my travelling companion by the Director of the Instituto de Geologia, Ingenieur Manuel Santillán. Dr. Müllerried speaks Spanish like a native of Mexico, where he has been working in geology for seventeen years. We went by bus to Puebla and Tehuacan in the state of Puebla. From Tehuacan we went by Ford car to Huajuapam in the state of Oaxaca. The trip was continued on horseback, with one pack mule to carry specimens, and Indian guides, to the former property of the Oaxaca Coal and Iron Company on the Rio Consuelo. We slept with our guides in an abandoned mine house, collected coal specimens and plant fossils, and returned the same way we came. The trip was made more difficult by the rainy season, still much in evidence in September.

In the mountainous region of northwestern Oaxaca we find at the bottom Archeozoic sediments with much volcanic intrusion. Above the Archeozoic, or igneous rocks, is a rather well developed system of Jurassic layers in the following arrangement: Malm (Upper Jurassic); Dogger (Middle Jurassic); and Lias (Lower Jurassic).

The Lias and Dogger are mostly fresh water deposits with coal seams and plant fossils, while the Malm and the uppermost Dogger are of marine origin and contain invertebrates. Above the Jurassic are marine Cretaceous deposits and above the Cretaceous are Pleistocene and alluvial deposits. It goes without saying that southern Mexico had no glaciation in the Pleistocene.

The fossil plants and the coal seams were found throughout the Lias and Dogger. They consisted mostly of Cycadophytes, but also of Cordaites and Cycadofilicales. Formerly the two latter groups were considered to have been extinct at the end of the Permian or not later than in the Triassic. The fact that they were found in the Lower and Middle Jurassic invites further exploration in this interesting region.

The Occurrence of Coal Balls in No. 6 Coal Bed at Nashville, Illinois[1]

G. H. Cady
State Geological Survey, Urbana, Illinois

Coal balls were found in the mine at Nashville about one year ago, April 9, 1935, by L. C. McCabe, C. G. Ball, and the writer, who were being taken through the mine by Mr. Samuel Day, mine manager and part owner of the mine. At a recent visit, April 17, 1936, by J. M. Schopf, Eugene Baysinger, and the writer two other pockets of coal balls were observed, both, however, much smaller than the one found in 1935, from which nearly 200 coal balls were recovered, after a considerable part of the accumulation had been cut down and discarded.

The Nashville mine is located at a central position in Washington County, Illinois, and is working Herrin (No. 6) coal at a depth of 407 feet. Including a basal "bone" coal layer the bed has the unusual thickness of about 9 feet. The thickness of the part mined above the bone coal is 5 1/6 to 6 feet.

The surface of the coal bed is even except for local depressions of relatively small area and an extensive channel-like depression along the east side of the mine which probably cuts entirely through the coal. There are a few places where the bed is broken for short distances by faults, none with a throw greater than about one-half the thickness of the bed. Except for the irregularity in the beds along the east side of the mine no definite alignment or arrangement of the depressions in the coal bed have been noted. These, of course, can only be observed in the face or ribs of rooms and entries but none seems to be traceable more than fifteen or twenty feet, and usually they do not extend this distance.

Three varieties of shale overlie the coal, each being in some places in direct contact with the coal bed. In addition there is to be seen over large areas of the mine the blanketing layer of the caprock, a limestone bed which at the shaft is reported as 10 feet in thickness. This limestone bed seems to be an unbroken, unjointed layer of limestone unaffected by the irregularities observed in the beds between it and the coal. The three varieties of shale are first, a gray shale, always when present immediately overlying the coal bed; second, a very argillaceous limestone or calcareous shale usually black to very dark gray in color but locally much purer limestone and of light gray color, which overlies either the coal or the gray shale into which it grades; and third, black

[1] Presented by permission of the Chief, State Geological Survey, Urbana.

sheety shale which always underlies the caprock, and may overlie the coal, the dark calcareous shale or limestone, or the gray shale. In general when the gray shale is present there is a transition upwards into the impure argillaceous limestone. The black slate is in abrupt contact with whatever strata underlie it but there is not uncommonly a thin streak of coal one-eighth to one-fourth inch in thickness at the bottom of this bed. This bed has a very uniform thickness of about 30 inches, the upper part being somewhat less carbonaceous and less indurated than the lower half. A few inches of rather soft shale lie immediately below the limestone. The base of the limestone, which is all that can be seen except in the shaft, is for the most part very even in its general appearance, but in detail this lower surface is a series of knobs and depressions several inches across and one or two inches deep. Here and there, however, the limestone extends downward in a knob-like protrusion several feet across at the top reaching almost to the top of the coal bed, thus they not uncommonly have a height of 20 to 30 inches.

From this description it is doubtless understood that there is involved in the stratigraphic succession a widespread coal bed, except where absent along a channel-like cut-out on the east side of the mine, a lenticular layer of gray shale which in general grades upward into a lenticular layer of argillaceous limestone or calcareous shale, a widespread bed of black sheety shale, and a massive limestone at the top.

The irregularities in the upper part of the bed are apparently all phenomena resulting from the lenticular character of the gray and calcareous shales. The lenses of such material in some instances thicken very gradually and widen the interval between the coal and the black slate. In other places they thicken very abruptly and very apparently represent deposition made in narrow depressions in the top of accumulated material. At such places there have been necessary adjustments in the coal and "slate" and in the arching and possibly faulting of the limestone because of the greater thickness of strata between the base of the coal bed and the base of the limestone where the shale lens is present. Such adjustments account for most of the structural irregularities in the mine.

The coal balls are found in the northern part of the mine where the immediate roof of the bed is the argillaceous lower limestone. At the locality where the largest accumulation was found the limestone was purer than usual and relatively massive, indicating an abundance of calcareous material present. They lie in the upper two or three feet of the bed and the adjacent coal is heavily impregnated with calcite facings.

Preservation of Plant Material in Coal Balls From Nashville, Illinois*

James M. Schopf
Illinois State Geological Survey, Urbana, Illinois

ABSTRACT

Calcification of plant materials in No. 6 coal, Clarkson mine, at Nashville, Illinois, has assumed three rather characteristic modes of occurrence:

(1) Elongated wood "stringers" which must represent portions of sizable logs. The preservation is in general poor.

(2) Nodules, i. e. "coal balls" in the more technical and restricted sense. These contain heterogeneous plant materials frequently in an excellent state of preservation.

(3) Encrusted nodules, i. e. a nodular center surrounded by a coaly shell and a more or less completely calcified outer layer. This

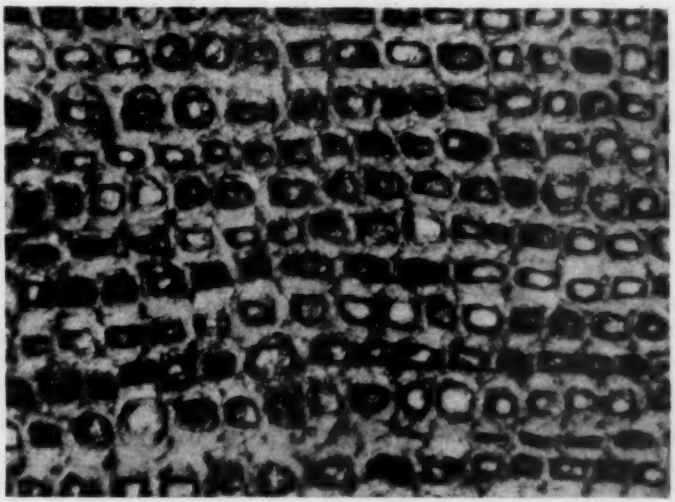

Fig. 1.—WOODY TISSUE FROM COAL BALL, CROSS-SECTION. Secondary cell walls prominent, lamellar portions nearly entirely replaced by calcite. Cells with dark lumens contain a filling of pyrite. Photographed by reflected light from an etched surface. Magnification 90 times.

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arrangement suggests that the calcite was deposited at two successive times separated by an interval of coal compaction.

The introduction of calcite seems indirectly associated with a sporadic "middle" limestone occurring directly over the coal wherever it is present.

The less well preserved woody tissues are interesting since it often appears that a considerable proportion of the original substance is missing. In nearly all cases the lamellar region of the cell wall seems to be the portion most extremely attacked. The secondary walls of these wood cells are present, represented by a somewhat laminated brownish (humified?) residue, each cell being definitely isolated from its neighbors as shown in the accompanying photograph.

It has been definitely established that lignin is concentrated in the middle lamella region in wood cells of present day plants, the secondary cell walls being predominately cellulosic. If this relation holds for these paleozoic woods, then the lignin has been depleted with proportional increase of cellulose. The process of calcification may have some direct bearing on this condition. It seems possible that the plant tissues which adjoined the areas of petrifaction and were converted into coal may likewise have been depleted of their lignin content.

Some support may be found in these observations for the contention of various authors that coals are derived from materials rich in cellulose and poor in lignin. It seems to the writer however, that such a condition as observed in these calcified woods, would hardly apply to the entire bed of coal.

Petrology of the Marine Sediments off the Mid-Atlantic Coast[1]

G. V. Cohee
University of Illinois, Urbana, Illinois

AREA AND SAMPLES

The area included the continental shelf off the coast from Delaware Bay north to Marthas Vineyard. Seven hundred samples from all parts of this area were studied. Mechanical analysis, including pipetting when necessary, was carried through for 200 samples and heavy mineral studies included 60 of the analyzed samples.

TYPES OF SEDIMENTS

The sediments of the continental shelf in this area are largely sand, but many zones of pebbles and silt are found scattered over all parts of the shelf. There are two principal zones which outline the distribution of the sediments in a general way. A southern zone from Delaware Bay to Block Island contains sediments composed almost entirely of sand with subordinate amounts of gravel but with almost as coarse sediment outside as near shore. The northern zone extending to Georges Bank has finer sediment on the outer portion of the shelf, but the inner portion shows the same patchy arrangement of coarse and fine sediment found farther south.

Histograms and medians show irregularities in grain size along and across the shelf and there is no general decrease in median size from the shore to the edge of the shelf.

PETROGRAPHY OF THE SANDS

Abundance of the minerals on the shelf.—The most abundant mineral on the shelf is quartz. Off Long Island feldspar, which is next in abundance, comprises from 20 to 30 per cent of the light fraction, with quartz making up almost all of the remainder. The sediments off New Jersey contain only 10 to 20 per cent feldspar.

The heavy minerals vary from .01 to 8.0 per cent in the sands. The amount of heavy minerals is usually lower in the samples near shore than in samples farther out on the shelf. Heavy minerals are even found with the silt and clay on the continental slope and on the deep ocean bottom at the base of the slope.

[1] From a doctor's thesis completed under the direction and supervision of Dr. F. P. Shepard of the Department of Geology and Geography of the University of Illinois.

Localized zones of heavy minerals.—The distribution of the heavy minerals over the sea bottom is very general, but some minerals are found to be diagnostic of certain zones. Hornblende is most abundant on the east side of the Hudson submarine valley off New York, especially in the silt-sand zone. Biotite is also common in this same zone. Angular salmon colored garnets are numerous on the New Jersey shelf near the submarine valley of the Hudson. These angular grains, in contrast to the well rounded grains of most of the shelf in this area, suggest that they were possibly derived from the glacial debris carried out by the streams during lowered sea-level. The cover of the shelf contains well rounded, frosted, and pitted pink garnets, staurolite, titanite, and tourmaline. These mineral grains may have been derived from reworked Coastal Plain sediments.

Authigenic minerals.—Glauconite was found in almost every sample examined, even off Long Island within three miles of the shore and in a depth of from 10 to 15 fathoms and at a little greater distance from shore but in the same depth of water off New Jersey. Since the glauconitic Cretaceous and lower Tertiary formations crop out along the shore north of Asbury Park, New Jersey, it is possible that much of the glauconite very near shore and for a short distance south may be derived from these formations.

Colony[2] states that no glauconite is present in the beach sands off Long Island. Its presence in the samples near shore and in shallow depths suggests conditions of non-deposition of sediment. Glauconite formation, according to Hadding[3], is favored in agitated waters with limited deposition of detritus, particularly fine detritus, and under reducing or neutral conditions.

Galliher[4] concluded that glauconite is formed by the alteration of biotite and that very little, if any, biotite would be found where there is much glauconite and conversely where the biotite abounds there would be little or no glauconite. In accord with Galliher's conclusions little biotite was found in samples containing much glauconite.

Limonite is widely distributed over all parts of the sandy zone of the shelf off New Jersey and Long Island but occurs in no great abundance. Where the limonite pellets are found very little biotite is present. Alexander[5], in a recent study of some continental shelf sediments, explains this condition by the oxidation of the biotite flakes to form the limonite pellets. A hardening of a gel-like hydrosol around the pellets gave the grains a varnish-like surface which probably resisted further chemical action.

[2] R. J. Colony, Source of Long Island and New Jersey Sands. Jour. Sed. Petrol. Vol. 2 (1932), p. 156.
[3] A. Hadding, Glauconite and Glauconitic Rocks Review by W. H. Twenhofel in Jour. Sed. Petrol. Vol. 2 (1932).
[4] E. W. Galliher, Geology of glauconite. A.A.P.G. Vol. 19 (1935), pp. 1569-1601.
[5] A. E. Alexander, A Petrographic and Petrologic Study of some Continental Sediments. Jour. Sed. Petrol. Vol. 4 (1934), pp. 12-22.

Pyrite is very abundant in the silt-sand zone east of the Hudson submarine canyon but is scarce off New Jersey and Long Island. However, small amounts have been found in samples within a short distance of both shores.

Calcium carbonate found in the sediments was in the form of shells and shell fragments. The shells exhibited weathered powdery surfaces suggesting solution rather than precipitation of the calcium carbonate.

Dr. Shepard and the writer believe that the wide distribution of authigenic minerals over all parts of the shelf indicates conditions without pronounced sedimentation whether these conditions be neutral or reducing. A period of oxidation during which limonite was formed may have preceeded the present neutral or reducing condition. The most favorable conditions must have existed at a time when the shore line was nearer the limonite areas and the water was shallower.

ORIGIN OF THE SEDIMENTS ON THE SHELF

The characteristic flat, elongated pebbles and well rounded heavy and light mineral grains suggest reworked materials from the old Cretaceous and Tertiary formations of the Coastal Plain. This material was left upon the shelf during the period of sub-aerial erosion in Pleistocene time[6].

South and east of Long Island for a short distance the sediment appears to be largely glacial debris of the outwash plain from the moraines of Long Island[7].

The silt which forms a secondary maximum in the samples of the silt-sand zone southeast of Long Island was possibly eroded from the morainic material of Georges Bank[8] by strong currents sweeping southwestwardly, and deposited on this part of the shelf where the water was deeper and the currents slackened.

Occasionally angular pebbles are found on various parts of the shelf which may have been carried out and dropped by ice-rafting.

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[6] F. P. Shepard, Submarine Valleys. Geog. Review, Vol. 23 (1933), p. 83.
[7] A. C. Veatch et. al: Underground water resources of Long Island, N. Y. U. S. G. S. Prof. Paper 44, p. 50.
[8] F. P. Shepard, J. M. Trefethen, G. V. Cohee, Origin of Georges Bank. Geol. Soc. Amer. Bull. Vol. 45 (1934) p. 291.

The Contact Between the Glenwood and Platteville Formations*

Stanley G. Elder
State Geological Survey and Northwestern University

Introduction.—Several phenomena at the contact of the Glenwood and Platteville formations have considerable significance. This contact is exposed along a line between Minneapolis, Minnesota, and Guttenberg, Iowa, along an arc through southwestern Wisconsin, and in the Oregon-Dixon area of Illinois. The Glenwood formation overlies the St. Peter sandstone and underlies the Platteville dolomite.

Difference in lithology between the upper Glenwood and the lower Platteville formations.—The Glenwood formation,[1] varying in thickness in exposures between 0 and 29 feet, is separated from the St. Peter sandstone by an erosional disconformity with a maximum relief of at least 45 feet. The St. Peter sandstone, therefore, was locally emergent throughout the deposition of the Glenwood formation and continuous into Platteville time.

The Glenwood formation is characterized by: (1) Diversity of rock types, grading from sandstone through shale to sandy dolomite, and (2) a peculiar texture of the sandstone.[2] A typical section of the formation in the vicinity of Oregon is as follows:

		Thickness Feet
(1)	Soft green shale	5½
(2)	Argillaceous sandstone	5½
(3)	Very sandy dolomite and dolomitic sandstone	12
(4)	Argillaceous sandstone	6

The green shale formation of the upper Glenwood contains more or less sand, principally in the lower half but locally in the upper half.

The lower Platteville formation consists of buff to brownish-gray dolomite which locally contains argillaceous and sandy layers, some local beds having a sand content of 77 per cent. Sandstone pebbles and phosphatic nodules occur in the basal Platteville beds which are more or less fossiliferous with brachiopods, gastropods, and triblobites, whereas the green shale beds of the upper Glenwood formation are sparingly fossiliferous with *Lingula*.

The contrast in lithology indicates a contrast in environments during the deposition of the Glenwood shale and the Platteville dolomite. Shallow muddy waters prevailed during Glenwood deposition and more

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or less clear waters existed during the deposition of the Platteville dolomite.

Rounded pebbles of sandstone in the basal Platteville dolomite.—Locally in the vicinity of Oregon, more or less rounded pebbles of sandstone varying from 3 to 12 mm. in the longest dimensions occur near the base of the Platteville dolomite. The interstices of the aggregates are filled with dolomite similar to the enclosing rock. All the grains of sand are of the St. Peter type, well-rounded and frosted. These show that the St. Peter sandstone was emergent during the deposition of the lower Platteville.

Phosphatic nodules in the basal Platteville dolomite.—The phosphatic nodules occur in a zone 10 to 30 inches thick in the basal dolomite, sandy dolomite, and dolomitic sandstone of the Platteville formation. This zone has been traced over a wide area in the Upper Mississippi Valley. The matrix beds are more or less pyritic and fossiliferous. The nodules, varying in shape and size, are of three types: (1) Gastropod molds, (2) varicolored and more or less glossy nodules, and (3) phosphatized and pyritized aggregates of sand.

Pettijohn[3] observed phosphatic nodules associated with large limestone pebbles and "corrosion surfaces" in dolomite or limestone in the basal Platteville formation near Minneapolis. The phosphatic pebbles, which are partly fragments of gastropods and brachiopods, are largely black and contain many fine crystals of pyrite. He postulated that during a period of non-deposition, following a period of normal limestone deposition, phosphoric acid was formed by the solution of shells and other carbonates in the limestone, and that this reacted under anaerobic or reducing conditions with ammonia generated by decaying organic matter to form phosphates, the sulphides accounting for the black color. He concluded that since phosphatic pebbles are associated with a period of non-deposition, they indicate disconformities.

In contrast to these observations on the basal Platteville beds, the writer has observed no limestone pebbles or corrosion surfaces or any evidence to indicate that the deposition of limestone preceded the period of non-deposition. It is believed, therefore, that it is not necessary for the deposition of limestone or dolomite to have preceded the period of non-deposition in order to produce conditions favorable to the formation of phosphatic nodules. The very first deposits of Platteville age are without fossils and contain only a few phosphatic nodules. The most abundant nodules are often in a very fossiliferous bed. It is postulated (1) that phosphorus, ammonia, and hydrogen sulphide were derived from the solution and decay of organic matter rich in phosphorus in amounts proportional to the rate of destruction of life, and (2) that the phosphates were precipitated under reducing conditions[4] about nuclei of undissolved phosphatic material within or outside of shells.

According to Aberdeen,[5] who studied the phosphatic pebbles at the base of the Decorah, the formation of the phosphates followed a period

of non-deposition brought about by the development of a profile of equilibrium. She postulated that the phosphates resulted from certain chemical reactions caused by the decay of life destroyed by a change of environment. These conditions would be equally applicable to explain the phosphatic nodules in the basal Platteville dolomite. The diastem or unconformity thus indicated by the presence of phosphatic nodules in the basal Platteville dolomite is further confirmed by the lack of gradation from Glenwood to Platteville beds.

Phosphatic nodules and disconformities are found at the base of the Platteville, Decorah, Galena,[6] Maquoketa,[7] and Edgewood[8] formations. This occurrence is significant and indicates that stratigraphic breaks may be located by the occurrence of phosphatic nodules.

Conclusions.—(1) The Glenwood and Platteville formations are separated by a disconformity, shown by: (a) The difference in lithology; (b) rounded pebbles of sandstone in the basal Platteville dolomite; (c) phosphate nodules in the basal Platteville dolomite.

(2) An historical resume is as follows: (a) Final deposition of the upper shale of the Glenwood formation; (b) a period of non-deposition; (c) change of relations of land and sea; (d) deposition of dolomite, sands, clays, and pebbles accompanied by a partial destruction of life, the decay of animal matter, and the precipitation of phosphatic nodules and pyrite; (e) normal deposition of Platteville dolomite.

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A Study of a Remarkable Meteor

A. J. James, M. D.
Houston, Texas

Twenty miles north of Peoria, the Illinois river is skirted on the east by a belt of timber about ten miles wide. In the midst of this forest, in the winter of 1875-76, there stood a large school house. A night session of a revival meeting was in progress with a crowded house. Although eight inches of snow covered the ground, a large, red hot stove made the house uncomfortably warm, the windows were open; time about 8:15 P. M.

The service is interrupted by cries "The house is on fire!" Looking through the windows it appears as light as day out of doors. The jam at the door delays the hurried exit. "Don't crowd, there is plenty time" the minister calls. Finally we are outside.

It seems really daylight, but everything is robed in a mantle of deep saffron. The crowd is gazing at an object in the heavens which appears to be nearly the size of the full moon. It is moving rather leisurely toward the east and is now very near the meridian. It's elevation from the southern horizon is between 50 and 60 degrees. The body shows a reddish-yellow disc with a distinct, circular limbus. No trail of light follows it.

We glue our eyes to the remarkable spectacle for a long while, maybe a full minute. It has now reached a point about half way between the meridian and the eastern horizon. There is an explosion, the body has divided into three large sections and a shower of sparks. The sparks quickly cease to emit light, and the large sections move forward at a considerable angle to each other. In a few seconds these sections explode again and the showers of sparks resulting cease to emit light quite a distance above the horizon.

The crowd has now gathered into groups listening to arguments, pro and con, as to the probability of this being the sign in the heavens which shall presage the end of the world. While many were talking excitedly, this absurd yet interesting comment was heard.

"I was sitting in a window and I saw the thing when it rose in the west, but I paid it no mind. I just thought it was the moon cutting up capers."

Finally the crowd reassembles in the house and the minister resumes his discourse. It is probably fifteen minutes since the meteoric display terminated. It begins to thunder, a soft deep toned rumble, but loud enough to make it difficult to hear the speaker. This continues for more

than a minute, and thus passes into history a meteoric visitation remarkable and awe inspiring in the extreme.

The newspapers reported observations of the meteor, but no account of its falling to the earth is remembered.

The above description is crude and, no doubt, inexact, but it is not imaginary, and it may serve, if considered with good judgment, as a basis for answering many intriguing questions in regard to the nature of this visitor to our planet.

Was the thunder caused by the flight through the atmosphere or by the explosions? If we grant that the thunder began fifteen minutes after the disappearance of the meteor, it must have been caused by the explosions. Sound travels about 180 miles in fifteen minutes and that is probably about the distance from us at the time of the explosions.

How high in the heavens was it when crossing the meridian?

It seemed to be moving leisurely—an indication of great distance. It had been in a state of incandescence and was therefore moving through the atmosphere for some minutes before reaching the meridian. The thickness of the atmosphere is variously estimated by different authorities. An encyclopedia published in 1925 estimates it from 300 to 500 miles. Other authorities estimate it 150 to 200 miles. It may be that the meteor was 200 miles from the earth when first seen in the west. It was constantly losing speed ahead and gaining acceleration of descent. After it crossed the meridian it traveled forward for something like 150 miles and exploded still quite high in the atmosphere. Probably an elevation of thirty miles and a distance of forty miles from the place of observation would be a fair estimate.

What dimensions may the meteor have had?

It was compared in size to the full moon. Even when hundreds of miles away in the western sky, it was mistaken for the moon by one spectator. The moon has an angular diameter of thirty minutes. A body at forty miles with an angular diameter of thirty minutes, must have a diameter of 1800 feet. Far beyond all reason. No doubt the glowing surface produced an exaggerated impression upon the retina. Still the body must have had considerable size. It produced a flood of light much greater than that of the full moon. It was incandescent for some time before the heat penetrated the core. A body forty feet in diameter at forty miles distance will have an angular diameter of fourtenths of a minute or about 1/75 of the angular diameter of the moon. A body of less diameter could hardly show a disc with a distinct limbus to the naked eye.

What was the probable constitution of the meteor?

The brightness of the light which shone on the earth suggests incandescent calcium or magnesium or both. The deep saffron coloration was quite certainly caused by glowing sodium vapor. A meteor composed of the heavy metals, as most meteors are, would hardly have occasion to explode. This meteor evidently had an inexplosive shell sur-

rounding an explosive core. The fact that the fragments ceased to emit light quickly after the explosions, indicates that they were of very low density, probably of a marked vesicular character. What could have caused the explosions anyway? Most likely the meteor was of homogeneous composition, a distinctly vesicular mass whose vesicles originally contained an explosive gas. Through long existence in empty space, the vesicles of the outer portion had evaporated their explosive contents, but, on account of the magnitude of the body, the core had not completely dried out.

Pumice stone is a mineral which fits the demands of the case quite perfectly. What gas fills the vesicles of pumice during its formation? LeConte's geology, page 85, says "Pumice is a peculiar, vesicular, variety of feldspathic lava". On page 86 he says "The gases expelled by volcanoes are steam, H_2S, SO_2, HCl, and CO_2. By far the most abundant of these is steam". Another author states "99 per cent of the gases escaping from volcanoes is steam". The explosive character of steam needs no comment.

If we grant that the meteor was of volcanic origin, we may still wonder if it was of earthly or lunar origin. There is evidence of the inconceivable violence of volcanic forces on the moon as well as on the earth. A mass of low density like pumice would be seriously hampered in its escape from the earth by the atmosphere. A given force acting on a projectile would drive it six times as high on the moon as on the earth. At the apex of its ascension, on the moon, the feeble lunar gravity would be opposed by a perceptable earth pull, which might be the deciding factor favoring a separate existence.

Why did the meteor move so leisurely in the heavens in apparent defiance of gravity?

To enter into this most interesting problem fully would prolong this discussion beyond reasonable bounds. Let it suffice to briefly mention a few of the factors operating, and anyone so inclined may elaborate them to his own enjoyment.

(1) If we grant that it was a satellite, it had very recently passed its perigee, and at this time it and the earth were relatively moving in opposite directions. For a while, gravity was entirely expended in overcoming this divergence.

(2) As gravity pulled it into a curved path, it had considerable head-on velocity; therefore much of gravity was consumed in overcoming its tangential stress.

(3) The meteor was observed by the people at the school house for 5 minutes or longer. In that 5 minutes, the earth rotated eastward 83 miles, thus prolonging the view.

(4) The meteor was evidently a large mass of very low density. Its glowing surface produced a strong current of ascending air. The buoyant force of which retarded to some extent gravitational acceleration.

The Economic Utilization of the Burlington Limestone in the Quincy Region*

J. E. Lamar[1]
Illinois State Geological Survey, Urbana, Illinois

The Burlington limestone formation crops out at a great many places in western and southwestern Illinois. It is characteristically cherty so that chert-free beds more than a few feet thick are generally rare. Although the formation is also cherty in the Quincy region, it is distinguished by the presence of a chert-free stratum 20 to 30 feet thick. It is this stratum which is now of chief commercial importance.

The chert-free bed is usually a coarse grained, crystalline crinoidal stone or medium crystalline limestone and is characterically white or very light gray. Chemically it is of high purity. A calcium carbonate content of over 98 per cent is usual and analyses showing 99 per cent are recorded. Magnesium carbonate is usually less than 1½ per cent and iron oxide, alumina, and silica together less than 1½ per cent.

Due to its white color and high calcium carbonate content the non-cherty Burlington limestone is used for a wide variety of purposes. Worthen in his "Geological Survey of Illinois," dated 1870, reports at Quincy a flourishing lime business which used the chert-free stone as a raw material. At the present time as well, large amounts of limestone are burned annually for lime which is sold for building purposes, for agriculture, for use in various chemical processes, and for making paper. In the form of small chips or when finely ground, the limestone is used for poultry grit, paints, kalsomine, rubber filler, wall board, stock feeds and medicines, polishes, putty, pottery making, floor filler, etc. Important uses for the broken stone include concrete aggregate, road metal, rubble, rip-rap, blast furnace flux and agricultural limestone. The value of the total output of the limestone and lime industry at Quincy in 1934 amounted to $200,000.

There are three open pit quarries producing crushed and broken stone in or near Quincy, three principal mines in the Mississippi bluff south of Quincy, and one mine along Mill Creek at Marblehead. At the four mines quarrying was conducted by open pit methods for some time but the overburden of loess and cherty limestone eventually became too heavy to be economically stripped. Subsurface mining was resorted to and is now employed by all three of the operators, although some

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[1] Geologist and Head, Non-fuels Division, Illinois State Geological Survey.

stone is also produced from open pits. Room and pillar mining methods are employed and trucks are used to haul the stone from the mine to the lime kilns or crushing plants.

Aside from the major production of high calcium limestone from the chert-free bed of Burlington limestone, other parts of the formation provide the raw materials for a number of comparatively small quarries which have been operated in the county, many of them periodically, for the production of agricultural limestone, road metal and rubble.

A new development in the Quincy area is the manufacture at Marblehead of rock wool, an insulating material. The raw material used is a blend of dolomitic Burlington limestone obtained from strata lying above the non-cherty Burlington stratum previously mentioned, and a siltstone of Kinderhook age which lies below the non-cherty stratum.

The crystalline, chert-free Burlington limestone takes a high polish and yields an attractive commercial marble, of light gray or white color. Much of it is stylolitic. In places parts of this stratum and other strata as well are colored buff by iron oxide and give rise to an attractive light brown stone for exterior construction which also appears to have promise for interior use. As colored marbles, rather than white marble are in demand at present, the Illinois Geological Survey some years ago undertook a preliminary study of means of coloring Illinois building stones, particularly those for use as interior decorative marble. It was found that the white Burlington took dyes and stains very satisfactorily and it appears that possibilities for increased utilization of the stone may lie along these lines.

The Glacial History of the Quincy, Illinois, Region

M. M. Leighton
Illinois State Geological Survey, Urbana, Illinois

Before the first ice-sheet invaded the Quincy region, the topography, drainage, and soils were quite different from those of today. The present valley of the Mississippi River was smaller and shallower and was not occupied by a master stream of the size of the present Mississippi. Most of the present tributaries of the Mississippi River in the Quincy region proper were not in evidence. The old valleys have been largely eradicated by the mantle of glacial drift and the present tributaries have chosen their courses with respect to the new surface, following the retreat of the ice-sheets. Limestone sinks probably dotted the upland surfaces where limestone was the surface bedrock. The soils of the region were those resulting from the weathering of the underlying bedrock formations. They consisted of two great groups: those which mantled the belt of limestone that extends from Quincy east nearly to Liberty, and those which mantled the "Coal Measures" formations from there on eastward.

The oncoming refrigeration of climate was world-wide in its effects. Great snowfields and ice-caps formed over the northern part of North America and northern Europe, and more and longer glaciers formed in the mountainous regions than exist now. Doubtless the same climatic factors operated in the southern hemisphere as in the northern hemisphere, but due to smaller land masses the glaciation of the southern hemisphere was much less pronounced. Four successive ice invasions occurred during the Glacial Period, separated by prolonged intervals of warm climate.

Three great centers of ice accumulation formed in Canada—one east of Hudson Bay, known as the Labradorean center, one west of Hudson Bay, known as the Keewatin center, and one in the Cordilleras of western Canada, known as the Cordilleran center. Only ice from the Keewatin center affected the present site of the city of Quincy, although a few miles to the eastward ice from the Labradorean center came to a halt in a later glacial age. The former is known as the Kansan ice invasion and the latter the Illinoian. Still older, or Nebraskan drift, is not definitely known to exist in the Quincy region but its presence is suspected. The Kansan ice radiated eastward well towards Peoria. The terminal moraine of the Illinoian drift trends in a northeast-southwest direction and approaches the eastern limits of the city.

At the time of the Kansan glaciation, there was probably a maximum amount of ice existing on the continents. It is estimated that in North America this amounted to 6,500,000 cubic miles, in Europe 1,700,-

000 cubic miles, Siberia 240,000 cubic miles, and other regions 1,700,-000 cubic miles, or a total of 10,140,000 cubic miles. This water had been taken from the oceans and when the ice-sheets melted it was returned. The difference in ocean level between the maximum glaciation of the Kansan ice age and the warmer portion of the Yarmouth interglacial age was probably something like 300 feet. Streams were extended out onto the continental shelves during the ice age and the valleys which they cut were drowned during the following interglacial age. The drainage lines close to the ice-sheets were probably depositing streams, whereas farther downstream with the lowering of the ocean level they were erosive and cut their valleys deeper.

Due to the filling of the old valleys by the glacial drift, the subsequent streams became superimposed upon hidden bedrock divides and rock spurs in many places. As a result, the present valleys are narrow where they have become incised in the bedrock and are wide where they have been cut in glacial fill. Mill Creek, including South Fork, shows many narrows bordered by cliffs of bedrock and wider portions with gentle pastoral slopes.

The Yarmouth interglacial age of warmer climate which succeeded the Kansan glacial age is very definitely recorded by the old soil and weathered zones developed on the Kansan drift which passes eastward for many scores of miles beneath the Illinoian drift. The changes which took place were oxidation from a blue color to yellowish and brownish, the leaching of limestone pebbles and other calcareous constituents to a depth of several feet, decomposition of the silicates in the upper few feet to produce a gumbo substance or hardpan, known as gumbotil, and a soil at the top from which the finer clay constituents were eluviated downward into the gumbotil. The amount of such change is such as to imply the lapse of some two to three hundred thousand years.

Then came the effects of another climatic change, an ice-sheet, the Illinoian, which had its source in the Labradorean glacial center of eastern Canada. This ice-sheet radiated to a more southern limit than any other, reaching a point a few miles south of Carbondale, Illinois, its western limit in the Quincy area reaching almost to the eastern outskirts of Quincy. Limits of the glacial outwash made by the melt water from the ice field are found in protected recesses in the valleys that drained away from the ice. The ice-sheet remained for sufficient length of time for the forward moving ice to bring forward material in such quantities as to build a belt of terminal moraine, of high country, at and beneath the ice front which was held more or less stationary by the rate of melting equalling the forward advance of the ice.

Again, after several scores of thousands of years of glacial conditions, the climate ameliorated and ushered in the Sangamon interglacial epoch. This epoch was warm, like that of the Yarmouth, and a soil and weathered zone was produced on the Illinoian drift similar to that on the Kansan drift, but the alteration did not take place to such

a degree or to such a depth as on the Kansan drift. In other words, the Sangamon interglacial epoch was something like 150,000 years in duration as compared to two or three hundred thousand years for the Yarmouth.

At the close of the Sangamon interglacial age, dust storms resulted in a thin mantling of the uplands and slopes with a brownish silt of a few inches to a few feet in depth. Upon this silt, a soil was formed before the Wisconsin glacial age began.

With another change to glacial climate, the Wisconsin glacial age arrived. This region, however, did not suffer actual glaciation during this time for the Iowan glacial lobe in Iowa fell short of this area by some 80 or 90 miles and the Tazewell glacial lobe in Illinois reached only as far west as Peoria, some 120 miles to the northeast. However, there were, no doubt, changes affecting this region as a result of the refrigeration. Enormous floods came down the Mississippi, and thick loess deposits were blown from the Mississippi River flats onto the adjacent uplands, burying the old soil of the late Sangamon loess and giving rise to new soil-making materials. It should be borne in mind that the constituents of loess are the constituents of glacial flour which were deposited by the glacial waters of the Mississippi in river bars, and the barrenness of these bars and the great width of the Mississippi valley gave the westerly winds just the conditions needed for dust storms of great magnitude over a considerable period of time, far greater than the dust storms of the present. This mantle of loess was a fortunate gift of nature to this area for the deposits are open-textured and are highly fertile. The deposits are thickest along the east side of the Mississippi River valley, reaching thicknesses of 30 feet or more, and thin eastward. Because they were blown by the westerly winds, the west side of the Mississippi River valley in Missouri contains thinner deposits and their agricultural productivity is considerably less.

When the Wisconsin ice-sheet was melting away from the Great Lakes area, the west end of Lake Superior discharged southward through the St. Croix River down the Mississippi River in large volume. This was a time of high floods, which ceased only when the Wisconsin ice had melted back sufficiently far for Lake Superior to become connected with Lake Michigan and Lake Huron. The water level then fell to the level of the Chicago outlet and later to the level of the St. Clair River near Detroit and Niagara Falls.

Another flood stage came when the retreating Wisconsin ice blocked the drainage of the Lake Winnepeg region in Canada and gave rise to an enormous glacial lake, Lake Agassiz, which drained south through the Minnesota and Mississippi River valleys. These floods had strong erosive powers and they swept away much of the glacial valley trains that had previously been deposited in the Mississippi River valley during the earlier portion of the Wisconsin ice age. However, when the floods subsided and the Mississippi River assumed smaller proportions

like those of the present stream, there was some refill. Today the Mississippi valley at Quincy has a fill of nearly 135 feet of silt, sand, and gravel resting on its bedrock bottom.

With the climatic change from cold to warm, the Recent age was ushered in.

The life of the glacial period.—Our records of the life of the glacial period are very fragmentary. They consist mainly of those fossil remains which are found here and there in the glacial deposits. Like all of the fossil record, it can be but a minute representation of the entire flora and fauna that lived during the glacial period. A student of life history, working in the Quincy area, notes the profound changes which had taken place in the life of the earth from the time that the Mississippian limestones underlying the glacial drift were laid down to the time that the glacial deposits were formed. The highest types of life found in the Mississippian strata are fishes and amphibians. Between that time and the beginning of the glacial period nearly two hundred million years elapsed and there was a great evolution of life forms, including the reptiles and birds of the Mesozoic and the generalized and more specialized mammaliam forms of the Cenozoic. The plant kingdom likewise was greatly changed. The tree-ferns and gymnosperms of the Mississippian and "Coal Measures" strata were augmented during the Mesozoic by the great angiosperm group of plants. The coming of these sweet-flowered and fruited forms, including the grasses, was probably responsible in large measure for the evolution of the great mammalian group.

When we come to the glacial deposits, we find that there are mastodons, mammoths, hairy rhinoceroses, bison, horses, sloths, glyptodents, saber-toothed tigers, deer, and many other forms roaming the continent in their respective prairie and forest habitats.

The late Dr. O. P. Hay of Carnegie Institute in Washington, has published a large volume listing and mapping the localities of the central region of North America where finds of these fossil forms have been made.

In Europe, the remains and crude artifacts of primitive man are found in strata of early glacial age. There we derive the most complete history of man. At the present time archeological researches in the great plains region and in the southwest are revealing evidences of probably late glacial man. Along the Mississippi River valley are mounds of prehistoric age in North America, but which are contemporary with historic man in Europe, Asia, and Africa. Finally, the Caucasian race arrived as a late comer to this continent and as we all know, his record is but a few hundreds of years in length. His arrival took place after all other forms of animal and plant life reached their present distribution and adjustment to the changes of the glacial period, and as a result of his coming all plant and animal life is being initiated into another period of rapid change.

In closing, it may be well to pause and orient ourselves with respect to geologic time. The paleontologist's time scale is given in the upper part of the illustration (Fig. 1) for the last two hundred million years of earth history. This dates back only to the Paleozoic era or the beginning of the Mesozoic era. You will note that the last one million years, during which man has lived upon the earth and which embraces the length of the glacial period, is but a minute fraction of this time.

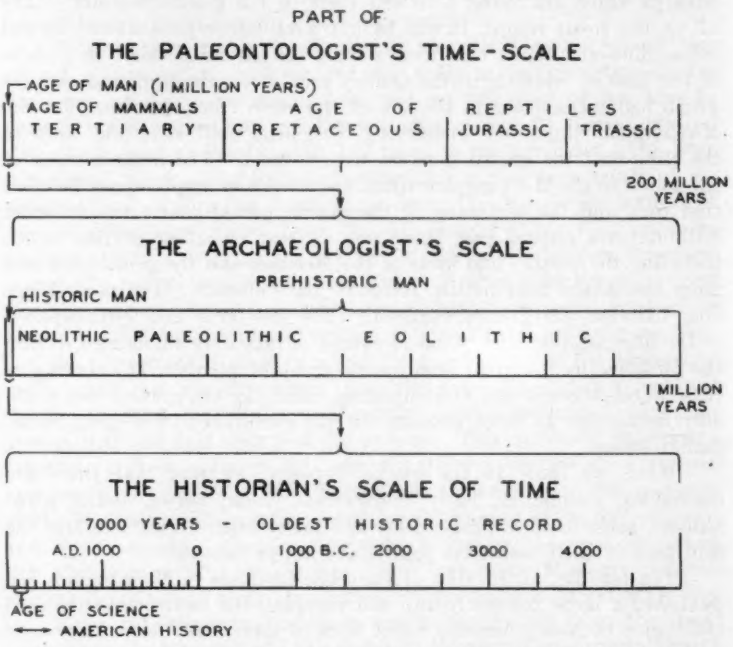

Fig. 1.—Chart showing time scales. (By Dr. Carey Croneis, University of Chicago.)

The archeologist's scale is a magnification of this period of earth history to cover both prehistoric man and historic man. Prehistoric man extends over the entire period of the glacial age to about 5000 B.C. The close of the glacial period was about 25,000 years ago.

The time unit for historic man is enlarged to the historian's scale of time, where it is shown that American history comprises but a minute portion of historic time and the age of science an even smaller portion. Another approach to the question of time ratios may be made by considering all geologic time to be compressed into the Christian Era. Then the Great Ice Age would have begun one year ago, the Recent Period nine days ago, the Historical Period day before yesterday, and the settlement of the Quincy region about one hour ago.

A New Means of Demonstrating Optic Figures

T. T. Quirke
University of Illinois, Urbana, Illinois

The recent introduction of a new polarizing substance of paper thickness known as *polaroid* has made possible certain demonstrations and experiments with the microscope not possible with the ordinary nicol prism.

If one places a basal section of a uni-axial crystal upon the stage of a microscope and places immediately above it a sheet of polaroid, he can project an optic figure, without the use of the microscope, onto a paper sheet or a ground glass held above the figure. By moving the ground glass, or even piece of paper, up and down above the thin section, one can easily demonstrate that the rays of light coming through the polarizer with the condensing lens in place are moving in a radiating direction so as to form a solid cone of light with rings of color, one within the other, and spaces of darkness which make the cross. If one places a cylinder of translucent material over the section one can obtain horizontal rings of color, again demonstrating the fact that the rays of light in the optic figure have a conical shape. An even more graphic illustration of this can be arranged by the use of a block of uranium glass which becomes luminous wherever a beam of light passes through it. These luminous beams unfortunately are very faint and good demonstrations are not possible except in a very dark room. With the use of uranium glass it is even possible to see that the light is divided into four separate beams by the black crosses. With bi-axial figures demonstration becomes even more striking. When a section cut normal to the acute bisectrix of the bi-axial mineral is placed on the stage with a plate of polaroid above it, transmitted light will throw a brilliant optic figure on a piece of ground glass held above the stage. A paper cylinder shows the emergence of the optic axes along the side of the cylinder, and a block of uranium glass shows the passage of light as a luminous cone without any suggestion of bands of darkness such as those which make the crosses in the uni-axial figures.

It occurred to the writer that with blocks of glass of known thickness it would be possible to make a calibration upon the ground glass surface in such a way as to enable one to read the optical angle of bi-axial minerals in a manner very similar to the method devised by Mallard. A little experimentation, however, shows that these axes can easily be projected onto a curved surface, and the writer devised a goniometer by which the optic angles in air could be read direct.

This device is made of two semicircles, preferably of celluloid, 5 cm. in radius which are attached to a base 10 cm. long and 2 cm. wide and with a hole 1 cm. in diameter in the middle. The semicircles are joined by a semi-translucent strip 2 cm. in width, which is a protractor numbered from zero at the zenith to 90° at each horizon. This is placed over a bi-axial section which gives a good optic figure, preferably in a position such that the acute bisectrix passes through the zenith. When the section is turned to the 45° position with the isogyres passing through the eyes, then the angle E can be read in both directions from zero in case the acute bisectrix is really vertical. Of course these two angles will be the same. In case the acute bisectrix is not vertical but not too eccentric, the sum of the two angles read from zero may be taken as being closely equivalent to 2E.

The angle 2E as measured on the goniometer scale may not be equal exactly to 2E. It is assumed that the rays of light which pass through the center of the optic eyes are exactly parallel to the radii of the goniometer, but in certain cases they may not be quite parallel because the point of convergence of the condensing lens may be either slightly above or slightly below the base line of the semicircular goniometer. That error is minimized in the author's device by having it made with a radius of 5 cm., which is so large in proportion to the probable lack of coincidence between the point of condensation of the lens and the center of the protractor's circle that any difference is practically negligible. In any case it seems impossible that this difference could amount to more than 1/10 cm. in a vertical direction, which, with a radius of 5 cm. and small angles, would be entirely insignificant and only in the case of readings where 2E is more than 40° could the error amount to more than 1°.

Another model of this same device is made with a radius of 2½ cm. This has the advantage of use on the stage of a microscope without withdrawing the barrel, but it has the disadvantage that the error discussed above becomes relatively much more serious, especially for minerals with high values for 2E.

The use of the goniometer here described is made possible only by the invention of polaroid, because with the ordinary nicol prism it would be impossible to bring the base of the goniometer any where near the point of convergence of the condensing lens. Aside from the use of this simple goniometer, polaroid seems to the writer to be of great help in demonstrating the nature of optic figures as seen under a polarizing microscope.

New Nepheline Syenites From Bigwood Township, Ontario*

T. T. Quirke
University of Illinois, Urbana, Illinois

INTRODUCTION

The author has collected from Bigwood Township, near French River, Sudbury District, Province of Ontario, specimens of syenite of types hitherto not named. In the Bigwood locality a suite of intrusive rocks ranges from quartz-bearing adamellite into nepheline-rich litchfieldite. The rocks of this suite are characterized by a general scarcity of dark constituents, by their content of soda-rich plagioclases and microperthite, and by an approximate balance in the amounts of potash and plagioclase feldspars. Among this suite are certain fine grained, pink rocks low in ferro-magnesian constituents and low also in their content of nepheline. Some fall, according to Johannsen's classification, between families 14, 15 and 10 and 11. If they had a little quartz they could be called sodaclase syenites and monzonites, but the occasional small content of nepheline allies even those free of nepheline (and free of quartz) with the families 14 and 15 rather than with 10 and 11.

For rocks falling in family 1114, those richer in potash than in soda feldspars and characteristically low in ferro-magnesian constituents, the name *Bigwoodite* is proposed. For rocks falling in family 2115, those with more plagioclase than potash feldspars, the name *Rutterite* is proposed. These names might have been supplanted by *nepheline-sodaclase syenite,* and *nepheline sodaclase monzonite,* but confusion might easily arise with *sodaclase nepheline syenite,* which is *litchfieldite,* 2119, and the term *nepheline sodaclase monzonite* might refer equally well to rocks numbered 2114 and 2115.

SYENITIC ROCK FACIES

The rocks described in this paper are found in the township of Bigwood, Sudbury District, Ontario, and in small parts of Delamere township and Parry Sound District adjoining. The major part of the bedrocks of this locality are well bedded, highly metamorphosed sediments of Huronian age. They enclose two large masses of apparently intrusive rocks. These masses are concordant with the foliation of the paragneisses and appear to be sill-like in shape. One of these masses is

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sodaclase adamellite; the other is a composite mass of gray nepheline syenite and pink syenites, which are characterized by compositions corresponding to rocks in Johannsen's classification of Families 2115P., 2114P., 1115P., and 1114P.

A considerable quantity of the pink syenite must have enough dark constituents to fall in family 2114, for which Brögger has already provided the name *fenite*[1]. But a distinctive feature of *Bigwoodite* is its low ferromagnesian content which first called the writer's attention to it as a possible source of glass rock. Consequently a distinctive name for that variety seems desirable. By increase in nepheline content it grades into family 2118, *lakarpite*[2], but the nepheline rich phases, although more striking, are probably not so widespread in outcrop as those with little or no nepheline. Similarly, the syenites in which the plagioclase content is greater than that of microperthite and potash feldspars grade from 2115, *rutterite*, with little or no nepheline into 2119, which is *litchfieldite*. There are leuco phases of *rutterite* and *litchfieldite* but they seem to be more rare than the leuco-rock called *bigwoodite*.

BIGWOODITE

Bigwoodite (1114) in the type locality lies in an elongated mass which appears to have replaced the country rock for a distance of about eight miles along, and about one mile across the strike. The rock is medium grained, composed essentially of microcline, albite, microperthite, and hornblende. The plagioclase varies in composition from approximately Ab_{90} to Ab_{100}. The microcline is irregularly intergrown with albite in microperthitic and less conventional textures. Hornblende is highly pleochroic and bright green, presumably high in soda. In many specimens aegirine-augite or biotite takes the place of the dark mineral. The dark minerals are arranged in places in bands or streaks which are discontinuous and even patchy in distribution. Potash feldspar in places is considerably in excess over albite and thereby causes the rock to go over into the family 2114. Calcite is a common accessory mineral, and in some facies of the rock constitutes an important proportion of the rock. Other phases, graphite-, corundum-, and nepheline-bearing might have been described but do not seem to the writer to require separate rock names. The association of this rock with nepheline bearing facies, its gradation into typical litchfieldite, allies it clearly with the nepheline rather than with the quartz bearing rocks. Otherwise, since it contains in typical facies neither quartz nor nepheline, its place would be on a line between 1115 and 1110.

RUTTERITE

Rutterite (2115) can be distinguished only with difficulty from *fenite* (2114) in the field, and is distinguished from *bigwoodite* and other members of the first class by its higher content of dark consti-

[1] and [2] These names provided by Prof. Johannsen's personal communication.

tuents. It is characteristically an equigranular, medium grained, dark pink rock which grades into the blue gray nepheline syenite by loss of dark constitutents and decrease in amount of the pink feldspar, microcline, and increase of gray albite. It grades also into the ruddy adamellite by increase in ferromagnesian minerals and addition of quartz. Different facies grade both into the quartz bearing rocks and into those with nepheline. It occupies a truly transitional position between the two groups.

It is composed essentially of feldspar with minor quantities of nepheline, quartz (epigenetic), biotite, graphite, magnetite, and amphibole. In places calcite is important. The feldspars are usually microperthite, microcline, and albite. In several specimens examined by Dr. R. H. Pegrum[3], Dr. Chas. Milton[4], and by the writer almost pure albite was noted.

The plagioclase varies in composition ordinarily between Ab_{90} and Ab_{100}.

NEPHELINE SYENITES

Within the exposure of bigwoodite there are two areas of nepheline syenite. The northern one extends from the northwest corner of Con. 6. Lot 12, Bigwood township nearly three and one-half miles to the northeast corner of Con. 3, Lot 10. The maximum width of the mass at the surface is one-half mile in Con. 5, Lot 11. The total area is about one square mile. The southern mass extends from the northeast end of Con. 2, Lot 11, Bigwood township to the north shore of Pickerel River, a distance of nearly three miles. Its greatest width is nearly three-quarters of a mile, and the total area of the body at the surface is about one and one-half square miles. This rock is well exposed on both banks of French river for about one-half mile in Lot 10.

In general the nepheline syenite may be described as a gray, medium to coarse grained, gneissoid rock composed essentially of white feldspar, pink nepheline, and black biotite or amphibole with magnetite, zircon, calcite, cancrinite, and sodalite frequently present as accessories[5]. The gneissic structure, which is a marked feature of this rock, is shown by the parallel arrangement of the biotite and amphibole and the tendency of the minerals to segregate into bands. The latter is especially true of the northern mass. Jointing in the rock is not particularly noticeable but it was observed in both bodies, and its direction is parallel to the jointing in the surrounding country gneiss, that is, east and west. On the French River, joint faces in the syenite occasionally form scarp faces on the river shore.

[3] R. H. Pegrum, field associate of the writer during the seasons 1925-27 who wrote a doctor's dissertation (hitherto unpublished) upon this and similar syenites.
[4] Charles Milton, formerly a student at the University of Illinois, where he prepared an unpublished study of certain specimens collected by the writer in Bigwood township.
[5] Minerals from the new nepheline syenite area, French River, Ontario, T. L. Walker and A. L. Parsons. University of Toronto Studies. Geol. Ser. No. 22, 1926. p. 6-14.

The nepheline syenites everywhere show conformable relations with the bigwoodite, and the gradation between these rocks is perfect in regard to both minerals and texture. Within the nepheline syenites there frequently occur coarse grained, pegmatitic masses and veins which are usually parallel to the foliation but occasionally cut across it at a low angle. A few veins in the nepheline syenite on the French River definitely cut across the foliation and in some cases they are parallel to the joints.

Both these nepheline syenite bodies in Johannsen's rock classification are litchfieldites (2119) with local variations to leuco-litchfieldite (1119) and mela-litchfieldite (3119).

ADAMELLITE

On the western side, the bigwoodite is in intimate intrusive contact with well bedded country gneisses, and on the east side with a slightly gneissose rock, a sodaclase adamellite (216″). The adamellite is altered with curious blotches of discoloration near the contact with the bigwoodite, and the bigwoodite, losing its characteristic composition by the addition of quartz, grades into syenite.

Perhaps the bigwoodite and nepheline syenites are connected genetically with the sodaclase adamellite, which in turn appears to be an offshoot of much larger masses known as the Dead Island sodaclase adamellites which lie chiefly to the south and west of the bigwoodite.

Pink and white massive rocks.—Near the bigwoodite there are also minor outcrops of feldspathic rock somewhat different from the bigwoodite. These rocks are nearly white where exposed. Near the northern line of lot 7, concession II, Bigwood township, about three-quarters of a mile west of the Canadian Pacific railway, white streaks lie within a dark, hornblendic gneiss which is the adamellite. The adamellite is coloured chiefly by the hornblende and its weathered products. Both the dark and white rocks are garnetiferous to about an equal degree, and seem to be distinguished from one another by the presence of hornblende in the dark rock, and by the gneissic texture characteristic of the dark rock and absent in the white streaks. These rocks are associated intimately with a fine, pink, alaskite-like gneiss in narrow layers and bands, which appears to be part of the bigwoodite. There appears in this place to be a gradation between the dark adamellite and the bigwoodite, both being garnetiferous, whereas the white streaks appear to be quite massive, containing unsheared feldspar crystals, apparent to the unaided eye. Another white rock outcrops near the railroad about one mile south of Rutter station. It is somewhat coarse grained and massive in texture, apparently composed solely of white feldspar and garnet. Under the microscope (Thin section 108—1925), however, quartz is apparent as interstitial filling between the feldspars. The groundmass is flecked with scarce, very small, dark green flakes of biotite. The garnets are distinctly skeletal, and of two kinds, the more

abundant being brown and the rarer being pale pink. Cloudy areas of plagioclase are replaced partly by bright, fresh, clear areas of younger microcline.

Examination of the pink rock under the microscope, shows (Thin section 109—1925) great similarity to the white rock. It is composed of albite partly replaced by both microcline and quartz. Grains of zircon and apatite are scattered throughout the specimen examined, and magnetite appears in both small and large grains. Mineralogic analyses of these rocks follow:

ROSIWAL ANALYSES (by volumes)

	(1)	(2)
Quartz	26.5	27.4
Microcline	39.6	41.2
Albite	30.7	21.7
Garnet	2.1	4.2
Biotite	0.6	0.4
Magnetite	——	0.1
Zircon	trace	trace
Apatite	0.3	trace

(1) White layers of massive rock, near Rutter. Leucosodaclase-adamellite, Rock number 116″.

(2) Pink layers of massive rock, near Rutter. Contact phase of bigwoodite (?). It might be called a sodaclase-alaskite, with Rock number 116′.

The foregoing analyses illustrate the close relation existing between the pink and the white rocks. The rather high content of quartz allies these rocks with the outer, or contact, phases of bigwoodite. The nearly massive texture of these alaskite-like rocks, their very high content of alkaline feldspars, and their sill- or dike-like shapes lead one to regard them as late arrivals in the episode of intrusion which produced the suite of rocks to which they belong.

MINERAL AND CHEMICAL CLASSIFICATION

This suite of rocks is marked first of all by its sodaclase characteristics. Some of the plagioclase feldspars examined under the microscope appeared to be almost pure albite. The rocks are usually low in ferromagnesian minerals. Such dark rocks as occur are in streaks or bands, local in development. Streakiness is quite characteristic. This streaky nature of the rocks makes accurate analysis or description of the rock types difficult, and makes areal mapping almost impossible. It is now uncertain whether 14 or 15 is the more prevalent of the two rock families. The sample listed as No. 4 in the chemical analyses was thought to be representative of family 2114, but upon analysis it was discovered to be 2115. It is certain that rocks of the family 14, in which potash feldspar is distinctly predominant over soda feldspar, are very prevalent in the rocks of Bigwood township. They vary from distinctly pale to dark colored types. The leucorock, bigwoodite (1114), is illustrated by the Rosiwal analyses as Nos. 1 and 2. These analyses are fairly representative of the very pale pink phase of the rock. Darker

phases, fenite (2114), are common, but very dark phases, shonkinite (3114), are rare and small in area.

These rocks show general excess of salic molecules over the femic; nevertheless, most of the adamellites and some of the nepheline bearing rocks fall in class II of the C. I. P. W. classification and in Class 2 of Johannsen's classification. Feldspars are extreme or dominant over both quartz and feldspathoids, consequently the rocks fall in orders 4, 5, and 6 of the C. I. P. W. classification and exclusively in order 1 of Johannsen's. In Johannsen's classification further separation depends first upon the presence of quartz or of feldspathoids, then upon the nature of the plagioclase, which is albitic (Ab_{90}—Ab_{100}) in all of these rocks, and upon the relative quantity of the potash and plagioclase feldspars. Many of these rocks fall in the sodaclase adamellite family 6″ — 7″, but grade through sodaclase monzonite into the definitely feldspathoid rocks, lakarpite and litchfieldite, with an unusual development of the transition rocks low in nepheline—bigwoodite, fenite, and rutterite. The chemical analyses show a definite gradation from sodaclase adamellite to leuco-litchfieldite. The gradation goes from class 4 to class 6, rutterite and bigwoodite syenites both being in class 5. The peralkalic nature of the series is shown by the fact that all the analyses fall within or nearly within rank 1. The relative importance of soda and potash is reflected in the range of subrangs from the dopotassic in bigwoodite and fenite to the dosodic in the litchfieldites.

ROSIWAL MINERALOGIC ANALYSES

	Johannsen's Rock Classification										
	1	2	3	4	5	6	7	8	9	10	11
Orthoclase	36.7	81.56	47.6	52.7	.....	.....	.....	.....	75.86	12.	3.24
Microcline	22.3	.....	.....	.....	47.1	44.6	42.	41.20	.....	45.	29.17
Microperthite	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.58
Albite	37.6	11.09	35.7	44.3	25.7	47.9	45.94	44.40	7.15	21.	40.34
Hornblende	3.1	.....	1.62	8.9	19.6	7.1	12.	14.22	.....	1.	.....
Biotite	.....	.....	6.23	1.9	.....	.....	.....	.....	.....	9.	2.28
Magnetite	.3	.....	1.88	trace	.....	trace	.....	.....	.....	1.	.....
Calcite	.....	.....	2.01	.....	.....	.....	.....	.....	.....	4.	.....
Apatite	.....	.....	.....	.....	.....	0.3	.02	.08	.....	.....	.73
Titanite	.....	.....	.....	.....	.....	.....	.04	.10	.....	.....	.....
Zircon	.....	.....	.....	.....	.....	0.1	.....	.....	.....	.....	.....
Nepheline	.....	7.35	4.32	.9	0.6	.....	.....	.....	12.95	7.	21.08
Cancrinite	.....	.....	.....	.....	.....	.....	.....	.....	2.47	.....	1.58
Epidote	.....	.....	.....	.....	.....	.....	.....	.....	1.57	.....	.....
Rock family	1114	1114	2114	2114	2114	2114	2115	2115	1118	2118	1119

1114, Bigwoodite. 2114, Fenite. 2115, Rutterite. 1118, Leuco-lakarpite. 2118, Lakarpite. 1119, Leuco-litchfieldite.

CHEMICAL ANALYSES

	1	2	3	4	5	6a	6b	6c
SiO_2	64.79	59.51	59.58	62.01	55.90	69.35	71.36	66.75
Al_2O_3	19.	18.09	18.11	13.59	22.12	14.38	13.93	17.96
Fe_2O_3	.39	2.50	.84	6.68	.96	1.80	.97	.25
FeO	.46	1.79	2.50	1.96	4.33	3.13	2.30	1.04
CaO	.76	1.48	2.98	2.98	.44	1.32	.50	2.50
MgO	.54	1.67	3.51	1.18	.37	.13	.25	1.88
Na_2O	4.76	4.97	3.76	5.17	8.35	4.05	3.84	4.16
K_2O	9.30	8.28	8.76	5.17	6.42	5.60	5.43	5.60
H_2O+	.....	.50	.....	.04	.57	.28	.48	.12
H_2O-	.....	.....	.....	.08	.....	trace	none	
TiO_2	.....	.....	.....	.71	.05	.29	.37	.08
P_2O_5	.....	.....	.....	.41	.....	.04	.08	.....
MnO	.....	.....	.....	.....	.14	.02	.....	.....
CO_2	.....	.89	.....	.....	.67	.05	trace	.....
S	.....	.....	.....	.08	.....	.25	.01	.....
BaO	.....	.....	.....	.....	.....	.05	.02	.....
.....	.....	.....	.....	less O/S .06	.....	less O/S .19	.07	.....
Total	100.00	99.68	100.04	100.00	100.32	100.55	99.64	100.34
C. I. P. W. classifications	I,5,1,2	II,5,1,2	II,5,1-2,2	II,5,1,3	I,6,1,4	I,4,1,3	I,4,1,3	I,4,1,3

1. Bigwoodite (1114) computed from Rosiwal analysis No. 1. Bigwood township.
2. Fenite (2114) computed from Rosiwal analysis No. 3. Bigwood township.
3. Fenite (2114) computed from Rosiwal analysis No. 5. Bigwood township.
4. Rutterite (2115) analyzed by R. J. C. Fabry. Bigwood township.
5. Leuco-litchfieldite (1119) analyzed by H. C. Rickaby[1]. Bigwood township.
6. Sodaclase-adamellite (216″). Dead Island Mass.
   - 6a. Lump sample collected by T. T. Quirke, analyzed by R. J. C. Fabry.
   - 6b. Chip samples collected by F. F. Grout, analyzed by Grout.
   - 6c. Rosiwal analysis from part of lump sample 6a, analyzed and computed by Quirke. All these samples numbered 6a, b, and c come from the same location on the east side of Dead Island.

[1] H. C. Rickaby. University of Toronto Studies. Geol. Ser. No. 22, 1926.

A Pleistocene Bog Deposit and Its Fossil Fauna

Elmer S. Riggs

Field Museum of Natural History, Chicago, Illinois

A fossil deposit near Minooka, Illinois, affords an example of animal-trap and bog preservation of remains combined in a way that presents features of unusual interest. The number and variety of mammals preserved in a small area is greater than has been observed elsewhere by this writer in bog deposits.

History.—In February, 1902, reports came to the Field Museum that bones of Mastodon had been found on a farm then owned by John Bamford, some three and one-half miles north of Minooka, in Kendall County, Illinois. The writer visited the place and found men working in a muddy pit eight by ten feet in size and at a depth of seven feet below the surface. Bones of bison, deer, and Mastodon had been encountered and much interest had been awakened in the neighborhood. The work was being done by the farmer with volunteer help from his neighbors. The pit was located in a slight natural depression of the ground including a small area of boggy land. Snow from the surface was melting and water flowing into the pit. A huge bucket, made from a half-barrel and attached to a rope and windlass, was being used to bail out the water. A young farmer, George Bedford, in hip boots appeared to be the natural leader of operations in the pit. This man, later known as Judge Bedford, of Morris, Illinois, became closely associated with development of this bone deposit.

The locality had, since the earliest settlement of the region, been the site of a spring which issued from the middle of this small area of boggy land. A wooden curbing had served to keep back the peat and formed a reservoir to hold and supply water as a stock-well. Planking laid over the boggy land offered a safe approach for men; fencing kept animals from entering upon the treacherous ground.

The farmer had, at a period of leisure in winter time, set about digging his stock well wider and deeper in order to have a reliable supply of water during the dry months of late summer and fall. At a depth of five feet the diggers had encountered a mass of smaller bones such as those of deer and bison. After passing through such a layer of some twenty inches in thickness, the workmen had encountered bones of Mastodon. This discovery had awakened interest which spread to the neighboring towns and attracted the press. A wide pit had been opened and many bones had been taken out. At this stage the Field Museum was notified and this writer visited the place.

Little attention had been paid to remains of the smaller animals. The bones, mostly of bison but some of deer, were scattered throughout the dump-heaps. The larger bones were being saved as carefully as unskilled men were able to do. A tusk had been uncovered to a length of some feet, a rope attached and men on the bank above eagerly hauling upon it had broken it at the middle. Not deterred by this needless destruction they had uncovered the remaining stump, again attached the rope and pulling sidewise had torn it from its socket in the skull. A fine specimen of adult Mastodon was thus broken up.

A careful count made by this writer, upon his arrival at the pit, disclosed teeth and jaws of six individuals of Mastodon. These animals ranged in size from young individuals with first dentition to adult males and females. Mr. Bamford was so impressed with the value of his discovery that no deal could be made with him to secure the specimens. He was willing to receive instructions as to how best to preserve the remains salvaged. The writer remained over night at the farm and left instructions that the tusks and jaws should be stowed in the farm cellar where they would dry out slowly.

For a period of years the larger bones, jaws and tusks were exhibited about the country and at County Fairs. When interest in them died out they were left in a barn—some of them fell to pieces in the farmyard. At this stage Mr. George Langford of Joliet, Illinois, a gentleman who had a taste for collecting natural history objects and a decided interest in fossils, salvaged the remains of the Bamford collection and conveyed it to his home. There he assembled some parts and repaired others so as to make sure of their further preservation. In the spring of 1918, Mr. Langford made known to the Field Museum that he was ready to part with the collection. Accordingly the writer went to the Langford home and packed up the entire lot. So after sixteen years the Bamford collection came to Field Museum and the best of it was placed on exhibition. Meanwhile the Bamford farm had passed to a new owner who looked with disfavor upon further excavation. The bog had been drained, the stock well done away with and the little basin converted into meadowland.

Through all the intervening years Judge George Bedford had retained his interest in the Bamford bone deposit and awaited opportunity to explore it further. He had become a staunch friend of Field Museum and had been a member of two field expeditions directed toward collecting fossil vertebrates. Accordingly, in the summer of 1929, Judge Bedford undertook to further explore the old bog-deposit and find out what remained of the specimens so hastily exploited twenty-seven years before. When this was accomplished, the residue was brought to Field Museum.

The bog proved to be of more limited extent than had been anticipated. In fact it was merely a product of the spring which, fed by ground-water from a gravel bed had broken through an overlying bed of boulder clay and had formed in it a basin of limited extent. Decayed

vegetation and wash from the surface, saturated with water from below had formed the mire. Masked by rank vegetation in summer and lightly frozen over in winter, this bog, with its tempting spring at center, had formed a trap which tempted animals to come into it to drink, and from time to time had ensnared numbers of them. Common humus acids developed by decaying vegetation had preserved the bones while the flesh was carried away in the usual processes of decay.

A cross-section of the spring had been constructed from data furnished by Judge Bedford.

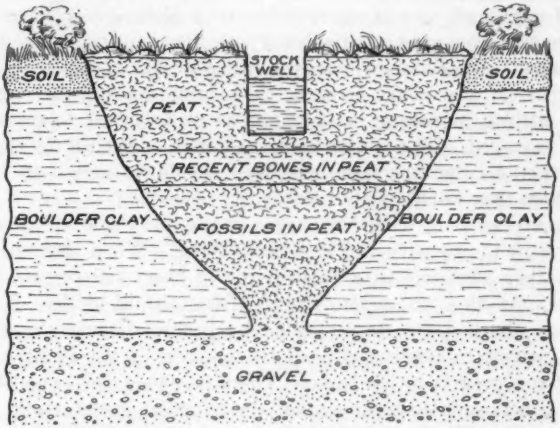

Fig. 1.—Section through peat bog on the Bamford Farm near Minooka, Illinois, as explored in 1902 and in 1929, showing basin eroded by spring in boulder clay, and filled with peaty matter; stratum of water-bearing gravel and layers of recent and fossil bones. Width of basin at surface 20 feet; depth from surface to gravel stratum, 14 feet; width of opening into basin below, 3 feet; layer of recent bones, 20 inches; of fossil bones, 7 feet.

This section shows a depth of black soil some twenty inches, about twelve feet of firm impervious clay, apparently boulder clay, and below this water-bearing gravel of unknown thickness. The spring occupied a basin twenty feet in diameter and fourteen feet in depth, penetrating the soil and clay stratum as far as the gravel bed below. The lower opening was about three feet in diameter.

The source of the spring is at once evident. The stratum of glacial gravel carried water, confined by the impervious stratum of clay, and under pressure from some higher source it had broken through the clay stratum and found outlet at the surface. Gradually the outlet had been enlarged forming the basin above described. Surface wash, combined with plant and animal humus and saturated with water of the spring formed a peat-bog upon which wet-land plants grew abundantly. Ani-

mals venturing upon this treacherous surface to reach the tempting spring-water had broken through and, unable to extricate themselves, had perished in the bog. Hence the accumulation of bones preserved by the usual bog action—exclusion from air and antiseptic action of humus acids. The entire history of the spring and its accumulation of trapped animals is post-glacial, animals such as bison and deer are of species now living.

LIST OF ANIMALS DETERMINED

MASTODON AMERICANUM

Parts of nine individuals. One skull, two pairs lower jaws and various bones of two mature adults.
Two pairs humeri and femera of young adults, mandibles and maxillaries of five young individuals.

ELEPHAS COLUMBI

One mandible, tusk and other bones, apparently a female.

CELVALCES SPECIES

One craneum with half beams of antlers.
One entire beam of antler with part of palm.
One metacarpal bone.

ALCES SP.

One broken antler.

CERVUS SP.

One broken antler.

BISON BISON

Miscellaneous bones of many individuals.

From lack of care in preserving the smaller bones taken from the bog it is not known what number of bison and deer may have been found but not preserved.

The predominance of *Mastodon* in the lower levels of the bog, indicates that it was by far the more common large animal to visit this spring—at least the one most frequently trapped. The lone specimen of *Elephas columbi,* in relation to the number of Mastodons, indicate a rarity consistent with the known occurrence of this species in post-glacial time. The presence of *Cervalces* represented by three adult individuals, as compared with the single specimen of a young *Alces,* would seem to indicate that the former species was the more common moose in this locality in post-glacial time. The great mass of bones of *Bison bison,* reported by Bedford and seen by the writer scattered about the dump heap in 1902, indicates that this species was most commonly trapped at the Bamford spring. The fact that bones of this animal lay higher than those enumerated and within a few feet of the surface, would indicate that this species frequented the spring at a later period. The number of *Cervus sp.* which may have been intermingled with the bison bones, and with them destroyed, cannot be estimated. From the nature of the trap, animals smaller than the deer would not often be caught, no matter how numerous they may have been in this region.

Volcanic Phenomena in the Craters of the Moon, Idaho

G. Frederick Shepherd

Museum of Science and Industry, Chicago, Illinois

This paper reports field observations made in the summer of 1935 in the Craters of the Moon area in Central Idaho, part of which is included in the National Monument of the same name. It is located at the north edge of the Snake River plain midway between the towns of Arco and Carey. A complete traverse across the desert to Minidoka and an airplane trip over a large portion of the lava fields furnished additional information reported here.

The surface features of this area are the results of the most recent volcanic activity of the Snake River lava plateau. As far as has been determined in other regions, where lava flows overlie till deposits, this activity took place in Pleistocene and Recent time and at three distinct periods of eruption, the last of which dates from 500 to 1000 years ago.

Many phases of volcanic activity are represented here. Most of the eruptions were of Hawaiian type, producing basic aa and pahoehoe flows in abundance. Numerous lava tubes are found in the latter flows. Cinder and spatter cones of Vesuvian type have been formed and there are indications that some of the eruptions may have been accompanied by *nuées ardentes* such as characterize eruptions of Mont Pelée altho its lavas are generally acidic.

The surface flows are extremely fresh and exposed in much the same condition as left on first cooling. A view from any elevation at once reveals the source and direction of flow of many of these lavas. Having this positive information as a check, I was interested in other criteria for determining the direction of flow, but found only one reliable criterion. No bent amygdule pipes were found such as have been described from the Keweenawan flows of northern Michigan. The bending of pahoehoe curls which form rough semi-circles with the convex side pointing in the direction of movement was the one type of index that could be used with at least local certainty.

One large irregular dike-like mass was observed at the edge of a flow where the lava had been forced from beneath the flow at a late stage in its eruption, oozing out between the edge of the flow and the older retaining wall beyond. It was traced for more than a half a mile and was from twenty to sixty feet high. The width could not be determined, but was at least thirty feet in places. Dikes of this character have been found along the crater rim of Mont Pelée and elsewhere.

The striking features of this region and the one furnishing the chief unsolved problem is the Great Rift and associated phenomena. As already mentioned, there have been three distinct periods of eruption

and the forces responsible for the Rift Zone were active thru all of them. The most obvious manifestation of this force is the alignment of the vents in a northwest-southeast direction forming a belt nearly three miles wide clearly shown on the topographic map of the Craters of the Moon, N. M.

If this line is projected north of the plain into the White Knob mountains a group of volcanoes known as the Lava Creek Vents is found at a distance of less than five miles. Not only is the group in line with the Rift Zone, but the vents themselves are similarly oriented. Their age is comparable to those on the plain and the Lava Creek Vents are several thousand feet higher in elevation.

This complete alignment of the cones in the Craters of the Moon led early investigators to call this an illustrious example of a fissure eruption and the National Monument was set aside as such. Of the true Icelandic type of fissure eruption, however, there was almost no evidence found in this entire region. Two questionable areas may be referred to other processes. The lavas have not been extruded along a great fissure, spreading out in large lake-like sheets, but have come from individual, widely separated vents.

The second feature of the Rift Zone is the parallelism of the numerous open fissures, predominantly oriented in the direction of the cones. These fissures are open fractures in the flows and cinder cones and are not sources of lava flows. The cracks range from a few feet to over a quarter of a mile in length, a few inches to over fifty feet in width, and some have a depth of nearly a hundred feet. No vertical or horizontal displacements could be found or other indications of faulting.

Exceptions to the linear arrangement of the rifts are found, usually at a considerable distance from the Rift Zone where there is a definite lack of orientation. In the Rift Zone itself there are a few areas where the fissures have been formed at an angle of 60° from the average trend.

The problem raised by these phenomena is to explain the force or forces which could determine the orientation of the vents and produce these fractures of similar alignment. The fissures are all tensional in character and have narrow U cross-sections. It is not impossible that the cinder cones were formed along similar rifts beneath the present surface flows, but this does not explain the open fractures in the latest of the lava flows. Also, if this were the case, one would expect to find feeder dikes along the Snake River canyon, but none have been reported. It does not seem probable, therefore, that the fissures determined the position of the vents, but that the rifts were produced by forces accompanying or associated with the eruptions.

Whatever may be the explanation, the force was tectonic and was undoubtedly connected with the major diastrophic disturbances of central Idaho. A regional investigation of the problem may throw some light on it considering the tectonic history of this region and the extrusion of the Snake and Columbia river lavas from every standpoint.

Progress in Geologic Mapping of Illinois, 1839-1936*

J. Marvin Weller
Illinois State Geological Survey, Urbana, Illinois

It is interesting historically that the first discovery of coal in North America was made in Illinois by Father Hennepin in the latter part of the seventeenth century. This can hardly be considered the beginning of geology in our State, however, because geological science did not make its appearance until another two hundred years had passed.

In the early part of the nineteenth century several exploring expeditions, mostly organized by various agencies of the Federal Government, passed through Illinois. Some of these parties included naturalists and more or less unrelated geological observations were included in the published reports of their findings. The first systematic study of the geology of any part of Illinois, however, was undertaken by David Dale Owen in 1839 for the Federal Land Office. His first report on the lead region centering around Galena, Illinois, and including adjacent parts of Wisconsin and Iowa was published in 1844. Included in this report was a map showing the extent of the Illinois Coal Field which was the first map showing with any accuracy any of the major geological features of the State.

In 1851 the first Geological Survey of Illinois was organized with Dr. J. G. Norwood as State Geologist. His studies covered the entire State and in 1858 he published a colored geological map on a scale of 50 miles to one inch. This map shows with a fair degree of accuracy the distribution of Silurian (including Ordovician = Lower Silurian), Devonian, Mountain Limestone (Middle Mississippian), Millstone Grit (Upper Mississippian or Chester), "Coal Measures" (Pennsylvanian), and Tertiary (including Cretaceous) rocks and was a very creditable piece of work for that time.

Norwood was succeeded by A. H. Worthen in 1858 and field work was continued until 1872. In 1875 Worthen published a geological map of the State on a scale of about 6 miles to one inch. The geological divisions recognized differed from Norwood's in that the St. Peter sandstone and Lower Magnesian limestone, Trenton Group (Galena-Platteville), Cincinnati Group (Maquoketa shale) and Upper Silurian-Niagara Group (Silurian) are differentiated, the Lower Carboniferous (Mississippian) is not subdivided and the "Coal Measures" (Pennsylvanian) is shown in two divisions.

* Published by the permission of the Chief, Illinois State Geological Survey.

The present Illinois State Geological Survey was organized in 1905 and in 1906 a new geological map prepared by Professor Stuart Weller on a scale of 12 miles to one inch was published. This was quite similar to Worthen's map of 1875. A few errors in Worthen's map were in some measure corrected but in some respects this map was less accurate than the preceeding one. This map was revised and republished in 1907. It differed from the map of 1906 principally by the addition of important alluvial areas and the abandonment of a two-fold division of the Pennsylvanian. Corrections resulting from field studies were made in parts of Calhoun and Jersey counties and to a lesser extent in the vicinity of Rock Island.

A new geological map on a scale of 8 miles to one inch was prepared and published by the Survey in 1912. Changes were of minor importance except for the revisions of the Silurian and various Ordovician boundaries in the northwest corner of the State, the differentiation and separate mapping of the Upper Mississippian (Chester), the more accurate delineation of the Mississippian and Pennsylvanian boundary in southwestern Illinois, and the inclusion of additional alluvial areas along the principal streams in the southern part of the State.

The most recent geological map appeared in 1917. It is principally distinguished from the last by revision of the Silurian and Ordovician boundaries in northeastern Illinois and the much more accurate representation of the distribution of Chester beds in southern Illinois which resulted from the extended field investigations of Professor Weller.

After nearly twenty years a new geological map of Illinois is now in preparation. Since 1917 an extensive program of field investigations has covered nearly the whole State which has involved the detailed mapping of many quadrangles and reconnaissance work elsewhere. According to present plans alluvial deposits of Recent and Pleistocene age will be indicated consistently throughout the State, Tertiary and Cretaceous beds in southern Illinois will be separated, the Pennsylvanian system will be subdivided into six or more parts, five divisions of the Mississippian will be distinguished and Lower, Middle and Upper Devonian will be shown. As on the last map the Silurian will be undivided and three units of the Ordovician will be recognized. Finally the small area of Cambrian outcrop now known to occur near Oregon will be distinguished.

PAPERS IN MEDICINE AND PUBLIC HEALTH

EXTRACT FROM THE REPORT OF THE SECRETARY

No program was planned for this section for the 1936 meeting. For this reason the following paper was presented before the Zoology Section.

The chairman for the 1937 meeting is to be appointed by the Council.

(Signed) W. M. LUCE, *Secretary*

Recent Research in Vibro-Tactile Sensitivity

Louis D. Goodfellow

Lecturer in Psychology, Northwestern University, and Associate Director of Research, American Institute for the Deaf-Blind

By the word, vibro-tactile, I refer to the organs involved in sensations that accompany the application of mechanical vibrations to the skin. The exact nature of this form of sensitivity is still in question, but we have evidence that both superficial and deep sensitivity are involved. Hence our term, vibro-tactile.

Professor Gault and his associates at Northwestern University have been interested in this form of sensitivity during more than a decade. By way of introduction, let me mention the reason for this great interest in the vibro-tactile field. It is a very practical one, namely, the enlargement of the uses of the vibro-tactile senses in relation to the education of the deaf. For those deafened individuals (and there are many of them) who do not have sufficient residual hearing to be helped by an earphone, some other approach must be substituted. The vibro-tactile senses, since they are the phylogenetic ancestor of hearing, appear to be the logical ones. Repeated experiments appear to demonstrate the practicability of this approach.

Probably all of you have touched the cone of your radio loudspeaker and have felt the vibration of the incoming speech or music. Although these vibrations are quite meaningless as felt by the finger-tip, when they are conducted to the ear they are readily distinguished and understood. In other words, the ear is sufficiently keen to respond to the subtle differences among them. The finger-tip is not so. Here then is the real problem: to develop techniques for accentuating these subtle differences so as to make them detectable by the finger-tip. This is a difficult task and already much time has been devoted to this end. The result of this effort has been the development of the Gault-Teletactor or "Phonotactor" as Dr. Gault now prefers to call it, an instrument by which one can feel speech or music. It consists of a microphone, special amplifier and vibrator upon which one places the fingers to feel the vibrations that correspond to the speaker's voice.

Five years ago, the Illinois State School of Deaf installed the Gault-Phonotactor for the use of a first grade class. Two years later, on their own initiative, they extended its use to fourteen classes. Each pupil has a vibrator on his desk which is connected to the teacher's microphone. As she speaks the pupils both read her lips and feel her words. Experiments show that the pupil's comprehension of speech is increased on the average 20 per cent because of these vibro-tactile cues.

I well remember a few years ago observing a teacher at work with the phonotactor. It was the first day of school, and a five year old lad was being introduced to the instrument. He appeared normal in every respect, but he had never heard a sound, and, therefore, did not know that such a thing as sound existed. The child's hand was placed upon the vibrator while the teacher spoke into the microphone. As he felt these vibrations in his fingers he appeared greatly interested in the new experience. Soon he noticed that he felt these vibrations only when the teacher held the microphone to her lips and made certain movements with her vocal apparatus. To us, hearing folk, the teacher was speaking, but to this deaf youngster, she was merely making queer movements with her lips and jaw which, in some mysterious way, caused this tingling in his fingers. Later the child placed the microphone to his own lips and tried to imitate his teacher, and in so doing he made probably the greatest discovery of his life. He discovered his voice. He found that when he exercised the vocal organs something happened—something which he and others could become aware of. Here then started the long process of teaching the child to make the delicate and accurate movements of the vocal musculature necessary to produce speech. In all this process the Gault-Phonotactor played a very useful part.

Although we are interested at the present time in developing the instrument for use as an adjunct to lip-reading and as a means of developing speech, we hope to extend the applications very greatly after we have mastered some of the difficult technical problems.

I think you will readily see that many educational and psychological problems arise from this work. They are being worked out in the State School for the Deaf, in our ow nprivate school, and in the psychological laboratory; but since they are not pertinent to this report we shall pass on. Probably our greatest emphasis at present is on the engineering and physical problems involved. We are confronted with the task of developing apparatus to compensate for what the finger lacks in sensitivity and in discriminating capacity. Here are many fascinating problems but they will not interest you. The fourth main division of our research projects centers around physiological and neurological problems. In the following pages I shall review our research on these items.

THE NATURE OF THE VIBRO-TACTILE SENSES

At least a dozen different experimenters have contributed evidence toward the isolation of specific end-organs involved in this form of sensitivity, but it is all quite incomplete and contradictory. Even the question of the relative role of deep and superficial sensitivity is still uncertain. Most of these studies [1–11] have been clinical observations of the independent loss or impairment of the two forms of sensitivity, and are interpreted as evidence of the existence of independent receptors responsible for vibratory sensitivity.

From the experimental approach, evidence pointing to the same conclusion is available. Bing, for example, by anaesthetizing various areas of the skin with cocaine, demonstrated that vibratory sensitivity is not markedly decreased, although other forms of sensitivity are destroyed. Katz found that the same thing holds after violent rubbing of the skin; namely, tactual sensitivity is impaired much more than vibratory sensitivity. We have found the same thing in our own laboratory, namely, the anaesthetizing the area being stimulated does not markedly decrease sensitivity although tactile sensitivity is entirely absent[12]. However, we doubt the significance of this experiment as an indication of the supreme importance of the deep sensitivity, since it is quite probable that in this case vibrations applied to the anaesthetized area of the skin were conducted through the anaesthetized skin to a normal area. The probability of this explanation has been demonstrated by showing that vibrations applied to the skin can be detected two feet away from the point of application.

Katz[13] argues that since the amplitude of vibration necessary to produce a sensation is far less than the movement required to give rise to tactual sensation, something other than touch must be involved. We discredit this form of reasoning since it would seem quite possible to account for the observed fact by the summation of rapid subliminal tactile impressions into a vibratory sensation. As further evidence of a differentiation he reports different reaction time and latent periods for tactile and vibratory senses.

A difference in the effect of fatigue has been reported. Katz found very little fatigue due to vibratory stimuli whereas touch fatigues quite rapidly. Kampie[14], however, reports different findings. In our laboratory we have carefully investigated the effect of vibratory stimuli versus pressure stimuli on vibratory sensitivity. The results show quite marked differences. Two minutes exposure to a vibratory stimulus decreases considerably one's vibratory sensitivity but two minutes exposure to a purely pressure stimulus shows no fatiguing effect on vibratory sensitivity.

Attempts have been made to correlate vibro-tactile sensitivity with cutaneous spots as mapped out by the traditional psychological experiments. One experimenter found some correlation with point spots from which he concluded that naked nerve endings picked up these vibratory stimuli. This finding, we have been repeatedly unable to verify, and we doubt very much whether correlation with any specific form of sensory experience will ever be established.

The following findings from our laboratory indicate the importance of deep sensitivity in vibro-tactile stimulation, although they by no

means indicate that vibro-tactile sensitivity is to be identified solely with deep sensitivity.

(a) The tongue, which is presumedly quite sensitive to touch is not very sensitive to vibratory stimuli. This is verified by Katz but refuted by Pollock, who says the tongue is quite sensitive to vibratory stimuli. This discrepancy in findings can be accounted for, we believe, by the different conditions under which the two results were obtained. Pollock used a much lighter vibraton than ours. Since our vibrator was large and massive, the damping effect of normal variations in pressure was negligible. It is quite possible that different end-organs are involved in the two situations. Furthermore, a different criterion of "more or less sensitive" was used. Our criterion of sensitivity is the threshold intensity, whereas Pollock's criterion is the observer's estimate on the intensity—psychologically a very different thing. We believe that those two facts, difference in apparatus and criterion, will adequately account for the different findings.

(b) The finger nail, which we would expect to find relatively more sensitive to vibratory stimuli than to tactual, is quite sensitive to the Phonotactor. The inference is that the vibratory sense and not touch is responsible for the greater sensitivity of the nail.

(c) Sensitivity is not markedly decreased by the wearing of a kid glove. The opposite is obviously true for the sense of touch.

(d) The back of the finger which contains many times fewer touch spots than the palmar surface is no less sensitive to vibrations. This lack of correlation between sensitivity and the distribution of touch spots suggests the predominant role of the vibratory sense.

(e) The sensitivity is not greatly changed by the use of a point instead of the diaphragm stimulating several square centimeters.

(f) The sole of the foot is less sensitive than the palm of the hand. Since previous experimenters have found the lower extremities less sensitive than the upper extremities to vibratory stimuli, we would expect this result if vibratory stimuli played a dominant role.

VIBRO-TACTILE SENSITIVITY

Although we do not know at present the specific end-organs responsible for the vibratory sensation, or the manner in which they function, we do have very definite data on the sensitivity and discriminatory capacity of these receptors. In our research on extending the uses of this type of sensitivity for the deaf, these data have a great practical value.

One of the first questions to be asked is the frequency range in the vibro-tactile sphere. Several attempts to measure this have been made in various laboratories, and each experimenter has reported a different upper limit. One of the first experimenters[15] reports 528 c.p.s. as the upper limit. Later experimenters[16, 17, 18] placed the upper limit at successively higher values ranging to 2700 c.p.s. We have evidence that all of these upper limits are artifacts, i. e., they are due to the functioning of the specific apparatus employed instead of true upper limits. By using a vibrator especially designed for the higher frequencies, and a high-gain amplifier, we[19] have had observers respond to vibrations as

high as 8000 c.p.s. We do not consider this figure as necessarily the upper threshold, but merely the limit to which our apparatus could function with the required amplitude.

Since the frequency range has in the past been determined by the intensity of the stimulation, we turn now to the study of intensity thresholds. Our measure of intensity is so many decibels above an arbitrary level, which in this case is the approximate threshold of the normal ear. Intensity thresholds have been determined for eight different frequency levels, and are given in Table I.

TABLE I.—THE SENSITIVITY OF THE FINGER-TIPS TO VIBRATORY STIMULI

Frequency	Sensitivity of finger-tip in decibels below our arbitrary level
64	41
128	53
256	69
512	89
1024	102
2048	115
4096	105
8192	91

The above thresholds were all determined for the finger-tip. Vibrotactile thresholds for other areas of the body are given in Table II.

TABLE II.—THE SENSITIVITY OF VARIOUS AREAS OF THE BODY TO VIBRATORY STIMULI IN DECIBELS BELOW THE SENSITIVITY OF THE NORMAL EAR

Area of body	Frequency		
	64	256	1024
1. Left index finger	40	67	95
2. Right index finger	44	75	104
3. Right index finger (wearing kid glove)	48	78	108
4. Right index finger (using sharp point instead of large conical diaphragm)	44	75	105
5. Back of the right index finger	45	74	105
6. Nail of the right index finger	43	70	92
7. Tip of tongue	59	90	118
8. Sole of foot	56	77	114
9. Palm of right hand	54	66	101
10. Inside surface of right fore arm	53	80	121
11. Inside surface of right fore arm shaved	53	79	124
12. Outside surface of right fore arm	49	76	114
13. Outside surface of right fore arm shaved	52	83	119

We are careful to distinguish between sensitivity and discriminatory capacities, since we find there is little correlation between the two—popular opinion to the contrary. Our interest in this was aroused a number of years ago when we discovered that one of our very best observers—best because he was able to make accurate discriminations of subtle differences in vibratory pattern—was quite insensitive in comparison with our other observers. We followed this up with a careful study and found very little relation between ability to sense and ability to discriminate.

As to the differential sensitivity we have found that trained observers can distinguish a difference in frequency of two vibratory stimuli provided the difference is at least 2½ per cent when the standard frequency is 400 d.v.sec. As to the ability to discriminate difference in intensity, a difference of 4 to 12 per cent, depending on the absolute intensity, is sufficient to enable trained observers to detect a difference.

Today accurate and specific data are available on the sensitivity of the vibro-tactile organs—their capacities and limitations. The following statements from laboratory findings indicate that all the important physical characteristics of speech can be detected by the finger-tip.

(a) The finger-tip can detect vibrations as high as 8,000 per second.
(b) It can differentiate intensity differences comparable to the ability of the normal ear.
(c) It can differentiate two pitches when the frequencies concerned differ by as little as 2½ per cent of the standard—400 d. v.
(d) It can detect differences in tones and beats.
(e) It can detect the individual tones in a chord and can discriminate between consonance and dissonance.
(f) It can detect differences in short intervals of time with 90 per cent of the accuracy of the ear.
(g) It is only one one-hundredth to one one-hundred-thousandth (depending on pitch) as sensitive as the normal ear. This is the only score on which the senses of touch and vibration do not compare favorably with the ear, but it is a deficiency which can be compensated for to a considerable degree by apparatus such as the Gault Phonotactor.

The ultimate success of the Phonotactor as a sole means of communication depends on the ability of the individual to interpret complex vibratory patterns. The deaf person will have to learn the meaning of each vibratory disturbance that he feels in his finger just as the normally hearing person has to learn the meaning of sound—the vibratory disturbances at his ear-drum. The task is not simple and a great deal more research is needed. However, three experiments done in this laboratory suggest that individuals can interpret complex vibratory patterns.

The first is an experiment in which a long series of four different musical intervals was presented to observers both auditorially and tactually. The result showed correlation of .53 $\pm$ 0.11 between a person's ability to identify intervals by hearing and his ability to identify them by touch. Furthermore, training in recognition of intervals by ear caused considerable improvement in the ability to recognize the same

intervals by touch. In short, our observers soon learned to recognize a musical interval by touch.

The second experiment is one in which two deaf and two normally hearing persons who had had no previous experience with the Phonotactor were given three half-hour periods of training in identifying five vowel and diphthongal sounds by touch. Then they were tested on the sounds and the results are shown in Table III.

TABLE III.—THE RECOGNITION OF SPEECH SOUNDS BY TOUCH (BASED ON 500 OBSERVATIONS BY 2 DEAF AND 2 HEARING PERSONS AFTER THREE HALF-HOUR PERIODS OF TRAINING).

Sound pronounced	Observer's response in per cent					Energy in milliwatts
	A	E	I	O	U	
A	70	12	6	6	6	0.27
E	12	60	14	9	5	0.08
I	6	13	72	4	5	0.17
O	11	8	6	66	8	0.46
U	7	5	5	7	76	0.12

The data in the table show, for example, that when "A" was spoken the observers interpreted it as "A" 70 per cent of the time. Twelve per cent of the time it was interpreted as "E" and 6 per cent of the time as "I", and "O", and "U".

The sounds were produced from a victrola made from the speech of an instructor in the School of Speech. The average value of the electrical energy going into the Phonotactor was measured for each sound and is given in Table III. It is clear from the data in the table that our observers did not differentiate these vibratory patterns on the basis of differences in intensity alone as is sometimes suggested by our critics. "A" and "E", it will be observed, were the most frequently confused, yet they differed widely in intensity in this particular experiment. On the other hand, "U" and "I" are frequently confused yet their respective intensities are of a similar magnitude. It must be pointed out that these simple experiments by no means prove that our observers detect quality differences but until further research is done we consider it quite likely that such is the case. The experiment is being repeated more carefully, using all the vowel sounds between the letters "b" and "t" (e.g., boot, boat, but, bit, bite, etc.) Tentative results indicate the same conclusions.

The third experiment on the interpretation of vibratory patterns is one in which observers were trained to recognize sentences as they were felt over the Phonotactor. The experimenter had before him a list of sentences of twelve syllables each. The observer had before him the same list except that the even numbered sentences had been omitted,

and were represented by their number only. The experimenter gave the signal "one" and read sentence number one several times. The observer, in this case, knew exactly what was being read. At the signal "two" the experimenter read sentence number two. This time, however, the observer did not know the actual sentence read but knew only its position in the list. After an extended period of training, the observers were tested on their ability to identify each vibratory pattern. In all cases, our observers learned to identify vibratory patterns when they were represented merely by a certain position in the list just as readily as when they were represented by the actual sentence being read. In brief, learning was necessary and then interpretation became possible.

We have presented data showing the great sensitivity and the discriminatory capacities of the vibro-tactile organs. Although we do not as yet know the exact anatomy or physiology involved, we have had considerable success in making this more or less neglected form of sensitivity serve human ends to a hitherto undreamed of degree.

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PAPERS IN PHYSICS

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

Of the eleven papers presented before the meeting of the Physics Section, ten are here represented. The other one was:

The Thomson Effect in Crystals, by Lester I. Bockstahler, Northwestern University, Evanston.

Harold Q. Fuller, Illinois College, Jacksonville, Illinois, was elected chairman of the Physics Section for the 1937 meeting.

(Signed) F. W. TANNER, *Chairman*

Electrical Discharge Phenomena in Insulation Under High Continuous Potentials

H. A. Brown and E. B. Paine

University of Illinois, Urbana, Illinois

Two years ago the authors reported before this group on their method of detecting the presence of electrical discharge phenomena in the insulation of electric wires and in the space between the outer surface of the wire insulation and a flat metal test plate upon which the test specimen rested. About a year ago the authors found that when high continuous potentials were applied to the conductor of an insulated wire and a metal plate touching the insulation, electrical discharge phenomena could be detected by means of suitably arranged filters and amplifiers. As this is believed to be a hitherto unobserved phenomenon in a dielectric it should be brought to the attention of those working in the fields of theoretical and applied electricity.

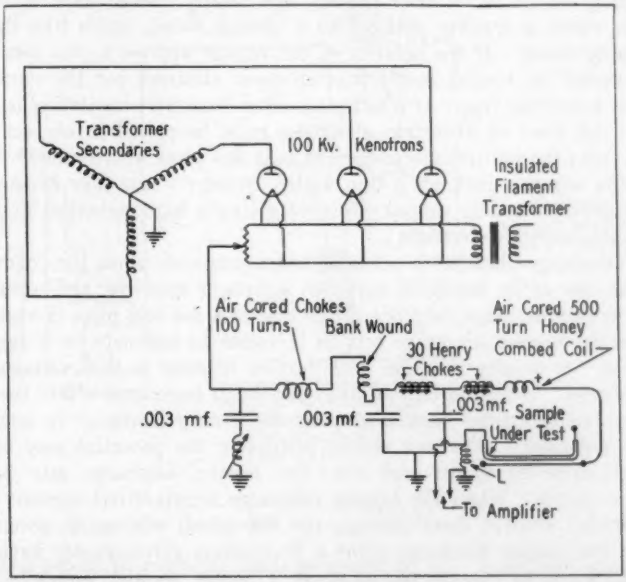

Fig. 1.—Rectifier filter for high voltage D. C. supply.

The high voltage d. c. supply is obtained from a three-phase kenotron tube rectifier and filter shown in Fig. 1. Three phase rectified output pulsates 13 per cent, and this must be smoothed out with an adequate filter. In addition to this, steep wave front discharges occur inside the glass envelopes of kenotron tubes at high potentials, and the

filter must be so designed as to suppress these also. A filter design that has proved effective for the authors is indicated in the figure. It is essential that the rectified d. c. potential at the output end where the test piece is connected be entirely free from any steep wave front disturbance and from any harmonic pulsation. The input connections to a high gain resistance coupled amplifier are placed across the inductance L in the figure. Hence any fluctuating current flowing through L will excite the amplifier. The amplifier must have a response that is constant for frequencies up to at least 20 kilocycles, and it must have a voltage gain of at least 75 decibels. A high grade telephone receiver and a good output rectifier type voltmeter should be provided to listen to and to obtain quantitative readings of the discharge intensity.

The test piece of dielectric such as a sample of insulated wire is placed upon the metal test plate and the latter connected to the positive terminal of the d. c. voltage supply, and the conductor of the test piece is negative when connected to ground through the inductance L. When the voltage is raised to a certain value there is noted occasional popping sounds in the telephone receiver. As the voltage is further raised the popping sounds occur more rapidly, and finally merge into a steady rattle which is quickly changed to a hissing sound, much like that of escaping steam. If the polarity of the voltage applied to the test piece is reversed the hissing sound is often never attained, but the sound remains a rattling type. If a test piece other than wire insulation is used, say a flat sheet of dielectric, electrodes must be placed in contact with each face; the positive electrode may be a flat plate with rounded edges, and the negative electrode a thin walled cylinder whose edge is rounded. This provides a ring shaped electrode giving a high potential gradient near this negative electrode.

Discharge phenomena occur at lower potentials when the conductor in the case of an insulated wire test sample is negative, and when the ring or cylinder edge electrode in the case of a flat test piece is negative. After the hissing discharge sets in it varies in intensity in a random fashion. It usually increases with further increase in d. c. voltage, but not always. Deterioration of the insulation sometimes alters the discharge characteristics such as causing the hissing discharge to occur at lower potentials. For new rubber insulation the potential may be increased some 20–30 per cent after the hissing discharge sets before failure occurs. When the hissing discharge begins direct current of a measurable amount flows through the test piece, whereas at potentials below the hissing discharge point a D'Arsonval galvanometer having a sensitivity of 10^{-9} amps. per m. m. at 1 meter showed no deflection. These observations indicate that when insulation is stressed beyond a critical value frequent pulses of unidirectional current pass through the solid body of the insulation, and that the direct current is not a steady stream of drifting electrons. Ionization of the solid dielectric has probably played an important part. The foregoing may be an aid in the study of the mechanism of break down of solid insulation.

A Cold Cathode Rectifier (demonstration)

Charles T. Knipp

Department of Physics, University of Illinois, Urbana, Illinois

This rectifier makes use of Hittorf's principle of limiting the expansion of Crookes dark space. Alternating voltages up to 12,000 have been rectified by it. The phenomenon was made visible: (a) by observing the trace of the discharge through the vacuum tube MM (styled the load), (b) by simultaneously observing the trace of the wave-form with a cathode ray oscillograph, and (c) by watching the changing Crookes dark space within the rectifier itself as the vacuum in it became higher and higher due to the charcoal-liquid air control.

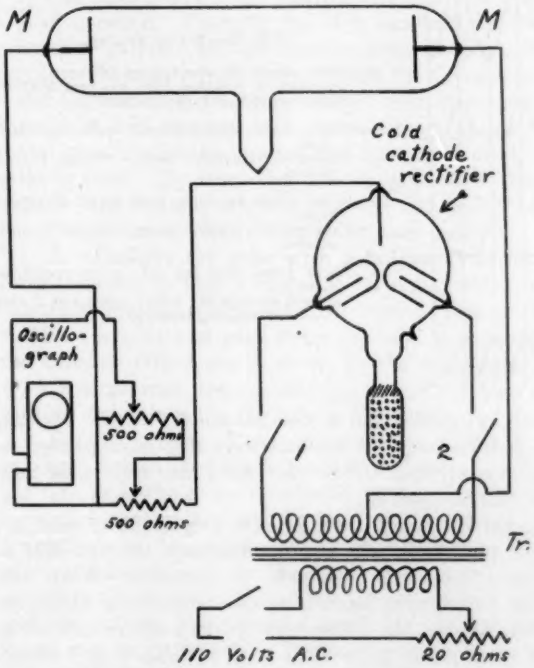

Fig. 1. — Complete set-up for both half and full wave rectification.

The set-up in complete form is shown in Fig. 1. There are four essential parts,—

(1) A 12,000 volt transformer (Thordarson) with a grounded secondary.

(2) The cold cathode rectifier with its three electrodes.

(3) A long large diametered discharge tube MM, the load.

(4) A 5-inch DuMont oscillograph (complete).

In addition to these, rheostats and switches are needed as shown in the figure.

Fig. 2a shows form of trace on oscillograph when the vacuum in the rectifier is *low*, and switch 1 alone is closed. There is no evidence of rectification, the alternating current passing with equal ease in either direction. The same type of curve results when switch 2 alone is closed.

If now the vacuum in the rectifier is made high by means of the charcoal-liquid air control and the switch 1 alone is closed, we get Fig. 2b, which shows half wave rectification. When switch 2 alone is closed we get Fig. 2c, which also shows half wave rectification, only that the half waves are shifted along the axis by a half period.

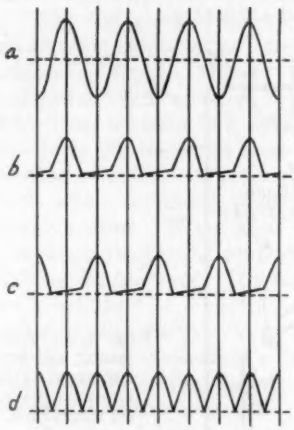

Fig. 2.—Wave Forms.

a—Wave form of alternating current.
Vacuum in rectifier low, no rectification.
Either switches 1 or 2 closed.

b—Wave form showing half wave rectification.
Vacuum in rectifier high. Switch 1 only closed.

c—Wave form showing half wave rectification.
Vacuum in rectifier high. Switch 2 only closed.

d—Wave form showing full wave rectification.
Vacuum in rectifier high. Switches 1 and 2 closed simultaneously.

On closing both switches 1 and 2 simultaneously, we get Fig. 2d, which is full wave rectification, i. e., the half wave that is suppressed in Fig. 2b (or 2c) is now utilized. This wave form also results, as may be seen, by superposing 2c upon 2b.

The visible discharge through the tube MM (the load) is most interesting. When the rectifier is soft, and the discharge through MM is unrectified, the striae extend from electrode to electrode. When the rectifier is hard, and rectification has set in, one electrode is distinctly anode, and the other cathode, the latter with its dark spaces extending out in front. This corresponds to 2b or 2c with switches 1 or 2 closed respectively.

Visually one can not distinguish between the discharges through MM on closing either switches 1 or 2, but when 1 and 2 are closed simultaneously (as for full wave rectification, Fig. 2d) the discharge through MM appears distinctly brighter, since more electrical energy is now forced through it.

The above phenomena were shown during the presentation of this paper.

Origin of Positive Rays in Cathode Ray Discharge Tubes Having Hollow Cathodes (demonstration)

Chas. T. Knipp and James E. Holcomb
Department of Physics, University of Illinois, Urbana, Illinois

The exact origin of the positive rays in a hollow cathode has become a moot question. Formerly the view was held, in the case of a hollow cylindrical cathode with an opening along the axis, that they had their origin in the negative glow just beyond the Crookes dark space, and fell, under the action of the strong electric field, towards the cathode, passed through it, and emerged as a compact beam of positive rays. A more recent view is that the positive rays have their origin *within* the hollow cathode itself. By mounting a mica vane on a track in front of the cathode face, the true origin of the rays can readily be demonstrated.

Two forms of positive ray tubes were used.

A. Positive ray tube with a hollow cylindrical cathode.—This form is shown in Fig. 1 when the vacuum (which is regulated by a charcoal-liquid air control) is right, cathode rays (—) leave the cathode surface normally and pass along the tube to the left. The position of the Crookes dark space is shown by the plane mn. The positive rays (+) emerge from the opening in the other end of the cylindrical cathode and pass along the tube to the right.

For the purpose of our demonstration a vane V was mounted on a carriage, carried on a track (shown in elevation in Fig. 1). By tilting the tube as a whole, the vane could be moved along the track and made to occupy any position out in front of the cathode, and thus intercept the cathode ray beam at any point along its path. This procedure should give us information as to the origin of the positive rays. If the origin is within the negative glow, then the vane when placed between that and the cathode face should cut off the positive ray beam. This was found *not* to be the case. The beam seemed to be as bright as before. The conclusion from this experiment follows that the positive rays have their origin *within* the hollow cathode.

This experiment, however, was not very conclusive, since the presence of the vane so near the cathode (for technical reasons) interfers with the total electrical energy passing between the electrodes A and C. Further experimentation with another form of positive ray tube seemed desirable.

B. Kunz[1] positive ray tube with hollow triangular cathodes.—The form of cathode consists of two triangular sheets of aluminium spaced about 2 mm. apart and riveted together. The term "hollow" relates to the space between. This structure constitutes the hollow cathode and is mounted as shown in side elevation in Fig. 2a, and in front elevation in Fig. 2b. The front and back faces of this hollow

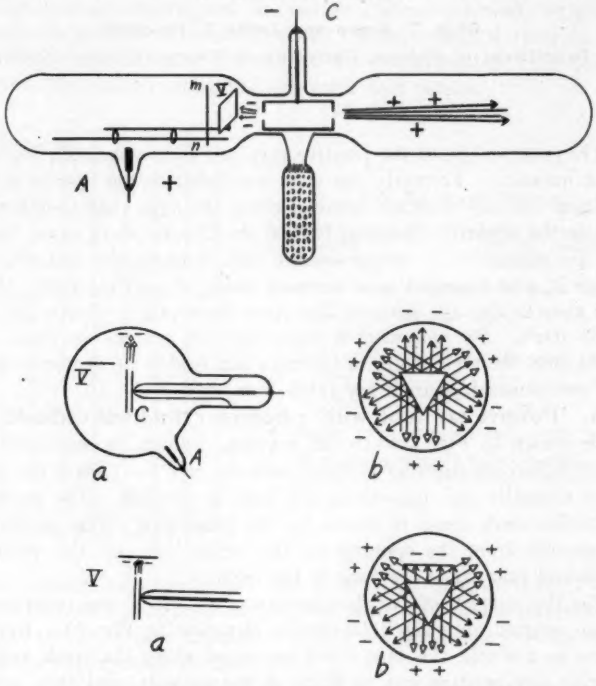

Fig. 1 (Top).—Cylindrical Hollow Cathode.

Fig. 2 (Center).—Kunz Hollow Triangular Cathode.

Fig. 3 (Bottom).—Kunz Hollow Triangular Cathode with Vane V in Place.

cathode are usually covered with sheet mica to prevent electrical discharges from them. When the discharge tube is exhausted to the proper degree and a high direct potential is applied to the anode and cathode, as shown in Fig. 2a, there result cathode rays and positive rays as shown in Fig. 2b. When the residual gas in the tube is helium, the cathode rays appear apple green in color, while the positive rays are a bright

[1] Phil. Mag., VI, XVI, p. 161, 1908.

red. The cathode rays issue perpendicularly from the edges of the hollow triangle, and are shown in the figure by closed arrows. The positive rays are shown with open heads and are, as in the experiment with the hollow cylindrical cathode, in the opposite direction of the corresponding cathode rays, thus emerging seemingly from the apexes of the hollow trianglar cathode. The relation of the positive rays to the cathode rays is thus the same as for the hollow cylindrical cathode (A) above, with the important difference that there are three sets of rays radiating out from the hollow triangular cathode at the same time, so that screening one set has but little effect on the electrical energy flowing through the tube. It should therefore be comparatively easy and reliable to study the origin of the positive rays by interposing a mica vane in the cathode rays of one set.

The position of the vane, V, drawn to one side so as not to interfere with the cathode rays coming from that edge of the hollow cathode, is also shown in Fig. 2a. The vane was then moved into position shown in Fig. 3a while the discharge was passing. The resultant arrangement of the beams is shown in Fig. 3b. The interception of the cathode ray beam did not in any way alter the positive ray beam in arrangement or in intensity. Nor was the brightness of the remaining two sets of beams around the triangle affected in any way.

This experiment demonstrates conclusively that the positive rays in these forms of positive ray tubes have their origin *within* the hollow space of the cathode.

The phenomenon, using the Kunz tube was demonstrated during the presentation of this paper.

A Convenient Method for Measuring the Speed of a Gyroscope

K. G. Larson
Augustana College, Rock Island, Illinois

If a gyroscope whose moment of inertia is I is spinning with a velocity of Ω radians per second around its horizontal axis, and if a torque of L dyne centimeters is acting perpendicular to the spin axis, the latter will rotate about a vertical axis through its point of support, this rotation being known as precession. If the velocity of precession is ω radians per second, then

$$L = I \omega \Omega$$

To test this relation we have used the following method.

The moment of inertia of the wheel is found by a weight and string wound around the shaft in the customary way. The wheel is then started by means of a motor and friction disc. By adjustment of the counterpoise and lever the precession is made slow, on the order of one revolution in 5 seconds, while the spin velocity is 30 or 40 revolutions per second. The thing which was new to us was the determination of the spin velocity. A disc of bakelite, 3 cm. in diameter, with six holes arranged in a circle, has been fixed on the shaft, and serves as a miniature siren. Compressed air is used with it, after the wheel has been started, and a sonometer wire quickly tuned to its pitch by sliding a bridge. The gyroscope is then allowed to precess while one revolution is accurately timed; immediately the siren is again used, and a second sonometer wire tuned to it. The vibration rate of the wires is then found by measuring lengths, and tuning to standard tuning forks. From these values is calculated the average spin velocity of the wheel, in radians per second, during the precession. The torque about the horizontal axis, due to the counterpoise, is found by using a spring balance to find the force in dynes necessary to produce equilibrium. The torque is

$$L = Fl$$

where l is the lever arm of this force.

The value thus obtained agrees reasonably well with the product of the moment of inertia, the spin velocity, and the precession velocity. Using it as a regular experiment in the general physics course, errors are usually within 5 per cent.

Heat Insulation

F. M. McClenahan
Monmouth College, Monmouth, Illinois

While engaged in developing a method for extracting the chemical values of pottery clays, attention was called to the necessity of providing some economic outlet or outlets for the ever present silica component derived from the clays.

The silica is in the form of nearly pure colloidal silicic acid. As produced by our method in the routine break-down of the clays it emerges as a material of extreme granular fineness. By actual measurement its particles have been found to be less than one-twenty-five thousandth of an inch in diameter. Several valuable outlets have been developed which depend for their effectiveness upon the fineness and chemical stability of the silica under the assumed operative conditions.

The particular value here emphasized is its adaptability to heat insulation. Early it was recognized that our silica physically is related closely to "silica gel" which may be obtained on the open market. However, it differs from this material in the fineness of its particles. On the other hand we have noted certain similarities to diatomaceous earth. We will give our method of preparation of this form of silica which we have named "Presil".

In the above mentioned process for the economic break-down of pottery clays to the end that metallurgical alumina and silica, each of the highest purity, be obtained, the latter material emerges as precipitated silicic acid, and separates as a soft wet pulp. This is dried, pulverized, and furnaced to low redness. The resulting powdery product is what we have named "Presil" (prepared silica). The apparent specific gravity of Presil powder is approximately 0.200. When moistened the particles adhere only when wet, but upon re-drying they fall apart readily from one another, and the same light powder results.

In order that this Presil be molded into brick or tile, or be used as a plaster, it must be made plastic. This may be brought about by adding some other material to the Presil, such as caustic or lime. Or, it may be possible to bring about a slight alteration of the particles themselves so that they will adhere to one another with reasonable tenacity after the moistened mixture shall have dried. We tried various expedients and finally devised the slight alteration of the particles them-

selves to such an extent that they hold to one another with marked tenacity after drying. The altered Presil we have named Plastosil (plastic silica).

When Plastosil is mixed thoroughly with water of the proper amount it takes on the general physical characteristics of glazer's putty. The plasticized batch may be molded, extruded, or otherwise shaped. It air-dries easily. The dried form does not warp, buckle, spall, or shrink markedly when furnaced to 1800° F. Its tensile strength is about 130 lbs. per sq. in. It does not have notable crushing strength. The apparent specific gravity of the dried product is 0.550. Microscopic inspection of the broken faces indicates the body to be shot through and through with air cells. Furthermore when those air cells are examined under the microscope they are seen to be smooth-lined, as though they are plastered by a fine textured cement. The walls of the cells appear as though the separate particles of Plastosil have been compacted densely each with its neighbor. The true density of this material, referring to tridymite, may be assumed quite reasonably to approximate 2.200. Thus we have a body, aid-dried, consisting of twenty per cent hard tridymite silica and eighty per cent air. The air-dried body takes up water to a large degree before showing signs of wetness and much more before it shows signs of softening. The furnaced body takes up water and air-dries readily but does not soften with excess of water. Its physical strength, however, is not as great as that of the air-dried body. The atmospheric hygroscopicity of the air-dried Plastosil is almost nil and that of the furnaced Plastosil is not detectable. The heat insulation value of a material depends directly upon the mass and stability of dissociated "dead air" pockets per unit area per unit thickness and also upon the heat conductivity of the material substance itself, which encloses those dead air pockets. The completeness of isolation of the dead air pockets from outside currents of air adds great technical value to the insulation material. The material should be non-combustible and antagonistic to a tolerance of vermin. It should remain rigid. It should be light. Last of all it should be inexpensive in itself and be applied inexpensively.

The coefficient heat transmissivity of air-dried Plastosil is about the same as that of prime cork. Subjected to atmospheric pressure on one side and vacuum on the other, Plastosil and prime cork are in a class by themselves with respect to transfer of air through the substance body. No other insulator approaches them in this excellent quality.

On account of the inexhaustible supply of silica from which Plastosil may be prepared, the inexpensiveness of the product, and its excellence and adaptability to so many and varied calls for an insulating material of its properties, we look for its wide use in house and building construction.

Electronic Transient Visualizers

Herbert J. Reich

University of Illinois, Urbana, Illinois

The field of application of the cathode-ray oscillograph can be greatly increased by the use of auxiliary equipment which makes possible the visual observation of circuit and line transients. The author has described a transient visualizer which accomplishes this result by means of a relay opened and closed by the sweep oscillator.[1] This device, while functioning perfectly at low frequency, had the limitations which are imposed by relay inertia and contact chatter. Experiments then in progress on the replacement of the relay by a vacuum tube circuit were not advanced sufficiently to justify more than a mention in that paper. The present paper covers a discussion of several types of electronic transient visualizers which have been developed during the past two and a half years.

In order to be of most general application it is essential that an electronic transient visualizer should have, at least during the initiation and duration of the transients, the characteristics of a switch. It should possess neither inductance, capacity, nor resistance, and should serve merely to open or close the circuit without in itself affecting the behavior of the circuit during the duration of the transient. This requirement immediately prohibits the use of devices in which the discharge or charge of a condenser or inductance is inherently associated with the action of that part of the switching circuit through which the transient current flows. The well-known parallel type of two-tube thyratron inverter circuit[2] fulfills the requirement if properly used. Since the operation of this circuit has been adequately discussed by a number of writers it does not seem advisable to discuss it here further than to state that the application of periodic voltage pulses to the grids results in a periodic transfer of anode current from one tube to the other.

Unmodified transients may be initiated in a transient circuit connected in series with the anode of either tube. If the grid excitation voltage is obtained from the sweep circuit which provides the linear time axis, then one transient can be produced for each sweep of the oscillograph spot, and a stationary image be obtained.

[1] "A Combination Sweep Circuit and Periodic Contactor, etc."; H. J. Reich; R. S. I.; 5; 7-9; (1934).

[2] "Hot Cathode Thyratrons"; A. W. Hull; G. E. Rev.; 32; 399; (1929) Electron Tubes in Industry; Keith Henney; 205-215; (McGraw-Hill; 1934).

A number of circuits based on the parallel type of inverter were developed by the author at the University of Illinois and by Mr. John Bennett at Cornell University[3] during the years of 1934 and 1935.

Although the operation of these parallel switching circuits was found to be excellent at high anode currents, the author observed that the action was somewhat erratic when an attempt was made to work with small currents. Further investigation revealed that the difficulty resulted from the fact that at small currents the anode current of grid-controlled arc-discharge tubes is not independent of grid bias, but that the current may be decreased and even cut off by the application of negative grid voltage.

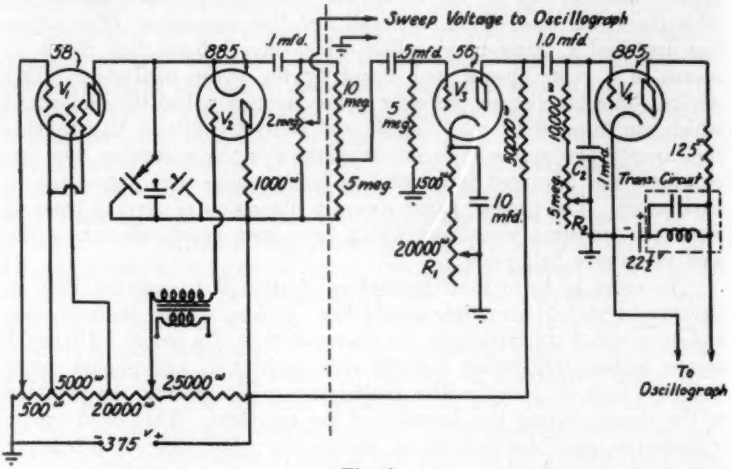

Fig. 1.

Fortunately this dependence of anode current upon grid voltage, although it is undesirable in a two-tube parallel circuit, makes possible the design of a simplified single-tube circuit. If the saw-tooth voltage of the sweep oscillator is applied to the grid of an 885 tube in such a direction that the sudden voltage jump at the end of the sweep makes the 885 grid negative, then, because of the rapidity of this change in voltage, the anode current of the 885 tube will fall to zero in a small fraction of a second. The tube fires instantaneously when the negative grid voltage has fallen to a critical value, the magnitude of which depends upon the applied anode voltage. The tube therefore has the required switching characteristics both for starting and interrupting current flow, and may be used in initiating repeated transients in synchronism with the sweep voltage. The complete combined sweep-circuit and single-tube transient visualizer is shown in the accompanying

[3] A thesis submitted for the degree of Master of Science at Cornell University, June, 1935, by John Bennett.

diagram. The portion of the circuit to the left of the dotted line is a standard sweep oscillator; the portion to the right represents the addition which must be made to the circuit for transient visualization. In many transient studies the 22½ volt battery in the visualizer circuit may be replaced by a tap on the main supply-voltage divider. The 125-ohm resistor in the anode circuit of V_4 may be reduced or eliminated if the resistance of the transient circuit is sufficient to limit the anode current to a value small enough so that the grid can extinguish the tube (50 milliamperes or less). The function of C_2 is to delay the firing of V_4 until after the cathode spot has returned to the beginning of its timing sweep. The conduction time of V_4 is adjusted by varying either R_1 or R_2.

The circuits which have been described in this paper have been found to be of considerable value in the lecture demonstration and laboratory study of circuit and line transients. The possibility of observing directly the effects of variation of circuit parameters is an especial advantage. Photographic records may be obtained by photographing the oscillograph screen, an uncorrected 2½-inch double-convex lens giving very satisfactory results. The high stability of the circuits is proved by the fact that sharp photographs are obtained with exposures of 15 seconds or more. An important feature of these circuits is that they can, with little complication, be added to a standard sweep oscillator.

Does the Crystal Structure of Solid Single Crystal Bismuth Exist After the Bismuth Crystal is Melted?

J. Henry Schroeder
Southern Illinois State Normal University, Carbondale, Illinois

Several investigators have asked this question because they have found that single crystal bismuth exhibits striking or peculiar physical properties near the melting point. Some of these physical properties, peculiar to solid single crystal bismuth, seemed to exist after the bismuth crystal had become molten. For example, Soroos,[1] working in the University of Iowa Laboratories, found that the thermo electric properties characteristic of solid single crystal bismuth existed to some extent in the molten bismuth until it reached a temperature about 8° C. above the melting point.

This would seem to indicate that the crystal structure of solid bismuth existed to some degree after the bismuth crystal had become molten.

Inasmuch as crystal structure also affects resistance it seems reasonable to expect that the resistance, characteristic of solid single crystal bismuth, should exist to some degree after the bismuth becomes molten.

The writer[2] of this paper conducted a series of experiments in which he measured the resistance of seven single crystals of bismuth of various orientations, at successive short intervals of time, as the temperature of the crystal slowly rose to about 10° C. above the melting point.

One of the chief difficulties encountered in this investigation was the determination of the exact time at which melting began and ended. Four different methods were used to determine these points. (1) The temperature was measured near the center of the crystal by a copper constantan thermo-couple. (2) A curve showing the temperature and time was plotted and the flat portion indicated the period in which melting took place. (3) Both junctions of a thermo-couple were placed within the furnace, one near the crystal and the other on the lid of the box holding the crystal. During melting the difference in temperature of these junctions became much greater. (4) The junctions of a thermo-couple were placed near each end of the crystal. The

[1] Adolph Soroos, Phys. Rev. 41, 516 (1932).
[2] J. Henry Schroeder, Master's Thesis, University of Iowa.

temperature of each junction was nearly the same until melting began, then the difference in temperature steadily increased until melting was complete.

The fourth method seemed to be the most accurate method because the junctions were near the ends of the crystal where the lead wires conducted heat away from the crystal, thus causing the ends to melt last.

In each of the methods described above, the low thermal conductivity of the bismuth crystal coupled with the relatively high thermal conductivity of the lead wires attached to each end of the crystal was the chief disturbing factor. The inaccuracy due to this cause was estimated to be at most about 2° C. It was also found that the resistance change expected of bismuth when it became completely melted, occurred within this 2° temperature range. This leads the writer to believe that liquid bismuth does not exhibit resistance characteristic of solid bismuth and that the crystal structure of bismuth does not exist in the molten bismuth.

A Laboratory Switchboard of Low Cost

Clarence R. Smith
Aurora College, Aurora, Illinois

The need for a laboratory switchboard is usually met either by some crude and incomplete makeshift, or some elaborately designed equipment involving considerable expense. For the school laboratory there are on the market several switchboards of excellent design, but at prices which, during recent economic conditions at least, many small laboratories could not afford to pay. The apparatus here described was devised after it became necessary to give up the purchase of a proposed equipment which would have cost approximately $300. In the physics department of Aurora College an equipment of the present design is in service and giving satisfaction. The total cost was about $50, not including labor, line wiring, or battery.

The purpose was to supply various laboratory and lecture room outlets with special voltages from a central part of the building. The voltages in this case consisted of regular A. C., generator D. C., and storage battery in steps of 2, 4, 6, 12, 18, and 24 volts. These were to be available at any or all of the outlets, which happened to be eight in number. The general layout is shown in Fig. 1 where the receptacles and connecting conduits are shown without wiring. Standard 4-inch steel outlet boxes are used throughout, with ½-inch conduit pipe for carrying the connecting wires. The box covers are of the type which is fitted with Hubbell polarized porcelain flush receptacles. Connections are made by rubber cords fitted with Hubbell polarized plug caps. The type with a cord grip should be used. The multipliers consist of two sets of receptacles, the five receptacles of each set being connected in parallel but distinct from the other set. They are used only when it is desired to have the same voltage on more than one outlet at a time. The conduit lengths shown connecting the multipliers to the rest of the system are merely for grounding and do not carry wires. An inspection of Fig. 1 will reveal that many combinations are possible. For example, suppose it is desired to have 4 volts on outlets 1, 2, 3, and 4; 12 volts on Nos. 5, 6, and 7; and 18 volts on No. 8. To accomplish all of this, the 4-volt terminal is plugged to one of the multipliers and thence to each of the four required outlets; the 12 volt terminal is plugged to the other multiplier and thence to outlets 5, 6, and 7, while the 24-volt terminal is plugged directly to outlet No. 8.

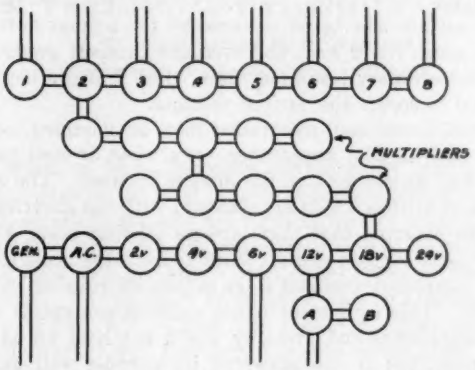

Fig. 1.—Arrangement of Outlets and Conduits. No Wiring Shown.

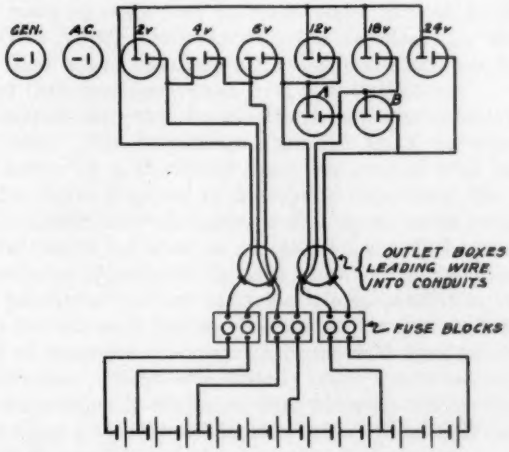

Fig. 2.—Wiring Diagram for Battery Outlets.

The battery is charged by connecting the generator D. C. with the proper terminal. Receptacles A and B are included so that the last two battery units may be charged independently as is already possible with each of the other units. Storage cells of the glass jar type were at first used but are now being replaced by the regular automobile type which are of much lower cost, and even the cheapest grade gives excellent service for ordinary laboratory uses. Fig. 2 shows how the battery cells are wired to secure the various voltages.

The outlet boxes and receptacles may be mounted near together and so as to make a neat appearance, on a wood or steel panel or even on a plaster wall as was done in the present instance. The entire equipment consists of fittings which are standard with the electrical trade.

It will be observed that there are no binding posts, switch blades or other live parts exposed and all wires (except the leads to the storage battery) are completely enclosed so as to pass all rules of city inspection and insurance. This equipment is not quite as convenient as the more expensive switchboards and probably would not hold up as long under extensive service, but it has answered its purpose well and its possibilities have been much appreciated during a period when more elaborate equipment could not be had. It is hoped that this description may be suggestive to other teachers who may have similar interests. Acknowledgment is due to Mr. Charles Singleterry, a student, who did most of the mechanical work and whose suggestions were valuable in revising the design.

Flexural Vibrations of Piezoelectric Quartz Bars

J. T. Tykociner and M. N. Woodruff
University of Illinois, Urbana, Illinois

Stabilization of high frequency oscillators by means of vibrating quartz crystals became the most important application of piezoelectricity. All radio broadcasting stations are piezoelectrically controlled oscillators in order to enable simultaneous radio transmission by hundreds of stations and to keep each of them within ± 50 cycles of the allotted frequency channel. The range of frequencies used in broadcasting extends from 550 to 21,520 KC. There are, however, other applications of oscillators of much lower frequencies in the range from 1 to 100 kc. Very little has been done to extend the methods of stabilization for these low frequencies. The main difficulty consists in the necessity of using very large crystals which are required if the usual longitudinal vibrations are applied. For frequencies below 15 kc quartz crystals of required dimensions are not available. To avoid this difficulty it is suggested to apply flexural vibrations of quartz bars. For this purpose an experimental study was made on twenty-one bars and plates cut of a large quartz crystal. Their length coincident with the electrical axis was from 0.7 to 13 cm., their height coincident with the optical axis was from 0.75 to 1.8 cm. and their thickness varied from 0.15 to 0.27 cm.

Two methods were used for the determination of natural frequencies of these crystals. For frequencies above 15 kc. a variable frequency oscillator driven by a thermionic tube was coupled with an aperiodic circuit. The latter consisted of a coupling inductance, the crystal bar mounted in a four-electrode holder and a copper oxide rectifier output meter. The quartz bar acted as an electro-mechanical resonator whenever the oscillator approached the fixed vibration frequency of the quartz bar. The polarity of the four electrodes placed parallel to the electrical axis of the bar was such that the direction of the electric field across the upper pair of electrodes was opposite to the field direction in the lower pair of electrodes. The piezoelectrically active quartz bar was thus subjected to compression in the upper part whenever tension was produced in the lower part and vice versa in accordance with alternating potentials produced by the oscillator at the two pairs of electrodes.

A pulse observed on the output meter indicated resonance for the particular setting of the variable condenser of the oscillator. For the determination of natural frequencies of flexurally vibrating bars which had a natural frequency below 15 kc. a compensating bridge method proved more sensitive. The crystal was mounted in a holder with two

pairs of electrodes placed parallel to the length axis of the crystal and inserted in one arm of the bridge in series with a resistance of the second arm. The third arm consisted of a variable condenser in series with a resistance of the fourth arm. The connection between the two adjacent resistances and that between the crystal holder and the variable condensers were used as points of potential difference at which energy was supplied from an oscillator of variable frequency. The potential difference at the two points where one resistance was connected to the variable condenser and the other resistance to the crystal mounting served to energize the input circuit of an amplifier. The output circuit of the latter was connected to a copper oxide rectifying detecting instrument which similarly, as in the first method, indicated a pulse whenever the frequency of the oscillator was made equal to the natural frequency of the resonating quartz bar. For each quartz bar rebalancing of the bridge was required. Longitudinal vibrations were also measured by a simpler method. The results of measurements confirmed the known relation that the natural frequency of the bars vibrating longitudinally is independent of the height (a) or thickness (t) of the bar and is a linear function of the length (b) of the bar. As to the flexural vibrations it was found that their natural frequencies do not correspond to the known relation $f = A\frac{a}{b^2}$. Frequencies calculated according to this relation gave values from 2 to 75 per cent larger than the measured ones. The deviation depended on the ratio a/b of the crystal. For crystals whose length was over ten times larger than its height, the measured fundamental frequency was in close agreement with the above relation. For crystals with a ratio $a/b = 0.5$ the discrepancy amounted to 40 per cent and for a square plate, $a/b = 1$, the discrepancy reached 60 per cent.

For the development and design of piezoelectrically controlled low frequency oscillators it was important to find precise relations between the natural frequencies and the dimensions of flexurally vibrating quartz crystals. By considering the rotary inertia of each cross-section of a vibrating bar in addition to its energy of translation Rayleigh derived a correction factor which is a function of a/b. Timoshenko extended the basic differential equations by including the effect of shear. The frequencies calculated with Rayleigh's correction were still too high and those calculated on the basis of the equations given by Timoshenko and Goens were too small as compared with the measured frequencies. From the experimental data collected on the twenty-one crystals a satisfactory expression was obtained for the frequency of flexural vibration. The following procedure was used.

Assuming that the relation searched for has the form $f = \frac{A}{B}\frac{a/b}{b}$ where A is a constant and B is a function of a/b. The ratios A/B were calculated for each crystal from the measured frequencies f and the

geometric dimensions a and b. These values A/B were then plotted against a/b. For B = 1 the value of the constant $A = 5.52 \times 10^5$ was obtained by extrapolation. Because of the uncertainty of extrapolating, this value which represents 1.03 times the velocity of propagation in the length direction was checked experimentally by measuring for each crystal its natural frequency of longitudinal vibration. The average experimental value was found to be $A = 5.54 \times 10^5$ cm. Dividing each of the values A/B by A, a curve for the relation B as function of a/b was obtained. It was found that it represents closely the relation $B = \sqrt{1 + 5.22\ (a/b)^2}$. Thus the natural frequency for flexural vibrations may be calculated from the expression $f = \dfrac{5.52 \times 10^5\, a}{\sqrt{1 + 5.22(a/b)^2\, b^2}}$ where a and b are the height and length of the crystal measured in cm.

The frequencies calculated from this formula deviate little from measured values. For 15 quartz bars this deviation was less than ± 1%, for 4 crystals it was from ± 1% to ± 1.8% and for two crystal plates which were the smallest (a = 1.05, b = 1.103 and 0.721 cm.) the deviation was — 6.83% and + 4.85% respectively. These latter two crystals with a/b = 0.957 and 1.467 respectively cannot be regarded as bars. They were included in this investigation for the purpose of determining the range of a/b within which the above formula can be applied.

The following conclusions may be made from this investigation:

(1) It is possible to produce flexural vibrations of quartz crystals in a plane containing its two largest dimensions even if the height (a) exceeds the length (b).

(2) A relation was obtained for the calculation of the natural frequencies of flexural vibrations from the dimensions of the crystals.

(3) This relation enables the determination of the dimensions of quartz resonators necessary for piezoelectric control of oscillators within a range of frequencies from about 3 to 120 kc. Its accuracy is better than ± 1.5 per cent for crystals whose ratio a/b does not exceed 0.5.

More details will be published in a bulletin of the University of Illinois Engineering Experiment Station.

Merits of a National Radio Fraternity in a Non-Technical College

O. B. Young

Southern Illinois State Normal University, Carbondale, Illinois

In the Physics Department of the Southern Illinois State Normal University, is being constructed a 1000 watt C.W. transmitter and a 500 watt phone set. The R.F. final stage will consist of two 852 tubes in push-pull and will be plate modulated, class B, by two 203A tubes in push-pull. At the present time a 100 watt C.W. transmitter is in operation and is licensed under the call, W9UIH.

As a consequence, this school is receiving wide publicity of high quality, appealing particularly to those who appreciate technical or applied work.

In connection with the radio equipment, has been organized the Epsilon Chapter of Synton, a National, Professional, Radio Fraternity. The benefits to the student members of this fraternity and of actual experience manipulating the set are many, some of which are unique. No other college organization, within the knowledge of the writer, answers so many needs of the members.

The student, to a considerable extent, masters the field of radio, which is a practical application of physics. He learns better the fundamentals of the theory courses. He develops manipulative technique and resourcefulness, which lead toward skillful laboratory and research work. He is made to assume responsibility of valuable equipment and to operate it in strict compliance with the rules and regulations of the Federal Communications Commission. This last type of training is not gained elsewhere in the non-technical college.

Amateur radio provides an excellent hobby—one in which a person may communicate easily with many other persons who have the same avocation. Frequently this hobby becomes a vocation and thus adds skilled workmen to the large industrial field of radio.

A member of the fraternity has professional advantages which aid in securing and in holding positions. Other qualifications being equal, he will be given preference over one who has no special interest in his major or minor subjects.

There are, of course, the usual social attractions of the college group. There is the gold key or emblem, patterned after the 204 tube. Little imagination is needed to find many other reasons—even though considerable time and expense are involved—why the installation of such an organization as Synton should be considered, particularly in the non-technical college.

PAPERS IN PSYCHOLOGY AND EDUCATION

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

All four of the papers presented on the program of the Section in Psychology and Education are here represented.

The maximum attendance at the meeting was about twenty-six.

The present chairman, Dr. Robert H. Gault, Department of Psychology, Northwestern University, Evanston, Illinois, was reelected to serve as chairman of the 1937 meeting.

(Signed) ROBERT H. GAULT, *Chairman*

Problems Connected With Administration and Supervision of Special Schools and Classes

Frank L. Beals

Assistant Superintendent of Schools, Chicago, Illinois

I shall begin by saying that the first and greatest problem is that created by combining the functions of the executive with those of the supervisor. Administration and supervision are not synonymous, nor do they imply a similarity of duties. To me the cleavage between the two is well defined.

Administration implies all of those activities which are concerned with organization and management, while supervision should be concerned only with the improvement of instruction. It may be that administration and supervision can be combined successfully in one of the narrow fields of atypical children, but certainly not where the two functions are all embracing.

In the larger fields supervision is a necessity if progress is to be made in instructional methods. However, there is divided opinion on that score. There are those who look upon supervision as a necessary evil, others who think of it as an unnecessary evil, while still others regard it as just plain evil. However, there are a few who see in supervision the basis of much good. The forward looking principal or teacher is not afraid of supervision. It is only the poorly prepared who resent it.

Let us consider nine atypical classifications:

(1) Schools and classes for crippled children.
(2) Schools and classes for truants and delinquents.
(3) Schools and classes for the deaf and hard of hearing.
(4) Open window rooms for anaemic children.
(5) Ungraded divisions for retarded or backward children.
(6) Corrective speech classes.
(7) Classes for epileptics.
(8) Classes in hospitals, homes, and camps.
(9) Classes for the blind and partially sighted.

It is easy to understand that with such a wide variety of exceptional children grouped under those various headings the problems for the executive and the supervisor are many and complex. Out of some two hundred fifty listed problems I have selected ten for discussion.

(1) **State laws and State support.**—Most laws governing the education of atypical children are enabling only. However, in some

instances, they are mandatory. In Illinois the law providing for the education of crippled children in special schools or classes is enabling only, although it is mandatory that provision be made for the instruction of crippled children. For each crippled child the State allows the sum of three hundred dollars over and above the amount necessary for the education of a normal child.

All schools and classes established under the law are subject to the supervision of the Superintendent of Public Instruction. Delinquent children also are cared for by a law which is enabling. The State provides for excess cost in the amount of $190.00 a year. For the blind and deaf and dumb children the State provides, under a Board of Education, for blind and deaf and dumb, for a minimum of $300.00 and a maximum of $500.00 each a year.

A big problem in this connection is to secure the actual money from the State.

(2) **Boards of Education.**—Naturally the school executive derives his authority from his Board of Education and he is responsible to it. Cost is a matter of concern to all boards, and keeping the cost of educating the atypical child down is a prime concern of the executive. In other words he is faced with the problem of furnishing the best in education at the least possible cost. However, Boards of Education are sympathetic toward exceptional children which helps somewhat to ease the difficulties with which the executive is faced.

(3) **Administrative staff.**—In any large scale undertaking an adequate administrative staff is a necessity. If such staff is to function most effectively, provision must be made for research, study, and planning. Obviously the busy executive can not do these things well and at the same time carry on his administrative duties. The problem here is to secure the staff. The staff, once it becomes available, is not a problem, but a solution.

(4) **Supervisory staff.**—The distinction between administration and supervision has been discussed and it is so well understood that there is no need to dwell on it here. However, there is need to stress the necessity for educational supervision of the proper kind in every atypical child. This is a problem controlled by Boards of Education, and, it will not be solved until they understand the necessity for trained supervisors.

(5) **Teacher selection.**—Within each state there should be a fixed standard of requirements for teachers of exceptional children. This applies particularly to teachers for the blind and partly sighted, for the deaf and hard of hearing, and for the mentally retarded. Here the supervisor could render an invaluable service in the matter of teacher selection.

(6) **Budget.**—So far as local Boards of Education are concerned they are loath to provide more for the handicapped than they do for the normal children. They take the stand that it is the State's business

to provide for exceptional children. This increases the number of problems connected with administration and supervision.

Where funds for the education of atypical children are tied down by hard and fast budget rules it makes operation to the best advantage of the children themselves impossible.

(7) **Housing.**—The difficulties here are almost too obvious to require comment. We may include with housing all of those facilities which should go with it.

Special housing and special facilities mean extra money, and money is all too difficult to come by. In the meantime we improvise and make most of existing buildings inadequate though they may be.

(8) **Curriculum.**—In the preparation of curricular material for the different deviates the supervisor in his particular field can render a most valuable service. In fact, the supervisor should play such an important part in the education of the heterologous child that I keep stressing the need for the supervisor. Perhaps nothing is more difficult than providing the best possible curriculum for each kind of exceptional child, and certainly the expert should have a hand in its preparation. Simply modifying existing curricular material does not solve the problem.

(9) **Personnel.**—This involves teacher selection and supervision for which we have little provision at present. It means that the whole matter is dumped in the lap of the executive, and he may do the best he can with it. Obviously the arrangement could be improved, although from the standpoint of the executive the problem is not difficult.

(10) **Elementary and secondary education.**—Until we can shake off the shackles of what is considered normal elementary and secondary education we shall make little progress in educating the child who is different. The dominance by standard types of education in the atypical fields retards progress in the latter. This situation will not be improved until education for the exceptional child is divorced from that for the normal child and wholly new methods of and materials for instruction are provided.

I hope that I have given a sufficient sampling of the problems involved in the administration and supervision of special schools and classes to make clear the necessity for a differentiation of administrative and supervisory functions and to interest you in the education of the handicapped child.

Preparing the Adolescent Mind for Living

David Condron
High School, Quincy, Illinois

The subject of adolescent psychology is too broad to do more than touch briefly. It is my purpose merely to show how one high school teacher in the field of Social Science has tried to prepare the adolescent mind for living.

Before one can live one must eat. It is hard to enjoy life when we have to worry about finances, food, clothing and shelter, our jobs, our bank accounts, and our old age. One of our most important problems is to make this economic system of ours work so that not just a few at the top, but that the millions of "common folks" can enjoy economic liberty (to work) and independence.

But while our economic problems are important, there are other parts of living that are equally as important, chief of which is character development. One of the greatest tragedies of the depression is our loss of confidence in each other. We lose faith in our politicians when they enter on such disgraceful campaigns as are being waged today between our major political parties. We lose faith in our business institutions when our Senate uncovers the policies of some of our munitions makers, and our utilities. Do we not owe it to our high school students to bring to their attention such beautiful and courageous characters as Christ, Pasteur, Washington, Lincoln, Thomas Mott Osbourne, Jane Addams, and many others.

Another important part of living is the appreciation of beauty. As Dr. Shannon pointed out in speaking on "The House of the Educated Man," we would do well to pause each day to see something beautiful, to remember something beautiful, and to do something beautiful. If we are to aid our adolescents to live we must help them to appreciate those acts that are beautiful, that lift one onto a higher plane of mental and emotional experience.

In attempting to prepare the adolescent mind for living I have striven to bring about the realization of (1) certain problems, (2) ideals in the solution of those problems, (3) methods of approaching those ideals. If we look at a very few of those problems selecting one in each field, economic, social and political it is not difficult to find excellent examples.

In the field of economics we may take the paradox of want in the midst of plenty. In bringing about the realization of this problem the students in Social Science are encouraged and assisted in a wide read-

ing. We study this problem from a local, national and international standpoint. We try to appreciate, for example, that according to conservative estimates the nations of the world as a whole are capable of supporting the people of the world as a whole on a reasonably high plane of living. In the United States we attempt to comprehend the phenomenon of a national capacity to produce an actual quantity of goods and services to an estimated value of well over 100 billion dollars while in 1932 we produced about 39 billion dollars worth.

When that problem has been understood we attempt to establish ideals. It is quite possible that on many of these ideals there may be a difference of opinion. Consequently they are somewhat elastic rather than hard and fast. The attempt is made to draw these ideals from the students themselves rather than attempting to force them to accept those of their instructor. The ideals are established through reading of books, study of the goals reached by other countries, and class discussion.

For example, at the present time we are devoting considerable time to the study of the consumers' cooperative movement. The students are reading books and pamphlets on the Consumers' Cooperative Movement in Japan, Sweden, Finland, Denmark, England and America. In some the ideal has caught the imagination and these young people are now ready for the third step namely that of ways and means of approaching that ideal.

Those who believe that the cooperative movement will result in the better and more equitable distribution of goods and services are learning that that goal can not be reached by mere fanciful wishing. They are learning first that they must educate themselves on the movement so that they will understand it and be able to discuss it intelligently. The next goal is that of educating other people. Here again a few are getting a practical lesson in the field of education through the realization of the conservatism of their friends, parents, and neighbors. They are learning that it will take a great deal of time, of work and effort in order to bring about their goal—the establishment of a Consumers' Cooperative in Quincy. There are some who are actively trying to educate others to what they believe a desirable movement. How much they will accomplish time alone will tell.

Those who do not believe in the movement are given every opportunity to study and state their side of the case. The class conflict of opinion is often very interesting and at times exciting.

In the field of social problems we might take the family and the subject of marriage and divorce. In this field the problem of broken and divorced homes, having children of divorced parents is not difficult to realize. The ideal of a family in which husband, wife, and children are joined together in happy union and cooperation is easily appreciated. The difficulty lies in the method of approaching that ideal. In attempting to understand the solution of the problem the student is brought back to the economic function of the family. He is encouraged

to study ways of fulfilling that function through reading such books as those of Ralph Borsodi, "This Ugly Civilization" and "Flight From the City." The effort is made to help the prospective brides and grooms understand the financial obligations of married life and the necessity of a budget, how they can raise their plane of living even though their wages may not be as high as desired through the production of goods in the home.

The student comes to know that married life is more than three meals a day and the physical attraction of each for the other. He sees that he must give and take, sacrifice as well as receive, understand the other's problems and moods as he expects the other to understand his, and to make life beautiful and worth while.

In the political field civil service furnishes a good example. The problem of men totally unfit morally, intellectually and all too frequently inadequately trained. The goal, public employees honest and upright in character, interested in social welfare, intellectually qualified to do the job.

In order to approach that goal he sees the need for abandoning the spoils system, for abolishing greed in the attaining of jobs, for educating the public to the waste and inefficiency of our present method of appointing public servants, and educating the public to the desire for a better system.

I do not wish to indicate that I am one hundred per cent successful in my attempt to help my students develop the correct attitude toward life. There are many many times when the results are particularly discouraging. The true value of our efforts however can not be measured at this time or by the report cards. When these adolescents actually begin to work, to establish their own homes, to live in a world outside of school, when some of the ideals they have established in school remain the guiding goals of their lives, then and then only can we feel gratified that our efforts have not been entirely wasted.

Motivated Remedial Reading in the High School

David Kopel

Northwestern University, Evanston, Illinois

In recognition of the large number of children who enter the high school with reading ability so low as to handicap materially (if not preclude success in) their work in most courses, an attempt is being made to devise an effective and feasible method of teaching these children to read efficiently. It is hoped that from the experimental work will emerge a remedial technique applicable in all high schools. This project is being developed at the Steinmetz High School.

The children selected for this special work are 1B and 1A students whose reading level, on standardized tests, is below that of the 7th grade, and who possess IQ's over 80. These youngsters have been placed in special English classes; their English period is devoted to remedial work in reading. In individual interviews teachers have made a thorough inventory of each child's vital interests, activities, and experiences: favorite leisure activities, hobbies, play preferences, vocational ambitions, wishes, personal problems and relationships, movie and radio preferences, and reading habits and experiences. These interviews, conducted during the regular English and study periods of the first few weeks of the semester, have served the purpose of: (1) Providing a basis for the teacher's real understanding of the individual; (2) effecting a friendly, sympathetic teacher-pupil relationship, important in all school endeavor, and essential in remedial work with children who have failed, who are frequently maladjusted, antagonistic, or indifferent, and whose *attitudes* consequently must be changed; and (3) obtaining an index to books and periodicals which the children will *want* to read, because these materials relate to the *children's* problems, *their* activities and interests, the things they want to know about.

Many new and vital materials, representing diverse interests, and appropriate for these children of limited reading ability, have been selected and are being made available. The library has cooperated in this phase of the program.

Day by day classroom procedures are carefully and specifically planned in advance (in weekly units). However, these schedules are flexible and may be adapted to special conditions and needs which may arise. Detailed descriptions of the daily programs, and samples of the forms devised for recording children's progress, are made available to those who visit the school. Typical procedures will be portrayed.

One very important phase of the project is a clinical set-up which provides for thorough physiological and psychological diagnosis of each child. The clinic, an extension of the Northwestern University Psycho-Educational Clinic directed by Dr. Witty and Dr. Kopel, is held weekly. Every Tuesday, from 10 A. M. to 3 P. M., visitors may observe examinations of children's vision, hearing, lateral dominance, intelligence, reading and general adjustment.

An informal conference of the entire staff (consisting of the director —Professor Witty, the psychologist—the writer, the four remedial teachers and their apprentice assistants, and an administrative assistant in immediate charge) takes place each Tuesday from 12:30 to 1:15 P. M. Problems and experiences of the previous week are discussed, and plans for the following week are formulated. Visitors are invited to attend these conferences and to observe the classes at work.

It should be understood that the program to be described is in the *developmental* stage; it is *experimental, tentative,* and *exploratory,* and only a *preliminary* to a mature and expanded program which will be initiated in various schools in 1936-1937.

Contributions of Physical Education to Adolescence

L. G. Kranz

Northwestern University, Evanston, Illinois

The first part of this paper attempts to build a physiologic and anatomic background for heart and circulatory considerations that are discussed in relation to physical education activities. This material is a summarization from such authorities as Percy Dawson, R. Tait McKenzie, Edward C. Schneider, John Mason Tyler, William H. Howell, Henry Gray and James H. McCurdy. The material is summarized in order to present the idea that there is a natural weakness of the heart during adolescence that would make necessary a protective program in activities. Heart conditions vary greatly and prescriptions should vary accordingly. Certain children of Junior and early Senior High School age develop a murmur of the heart with considerable irregularity of cardiac action. There is no organic disease and the condition is recognized as adolescent heart. These cases improve markedly under regular, fairly vigorous exercise that avoids continuance after fatigue. Competition for these children is not desirable, particularly competition of the inter-scholastic type. Many boys are sacrificed on the alter of successful athletic teams through lack of control of high school inter-scholastic competition.

The paper then discusses the values of prescribed exercise in relation to the heart, the lungs, and the weight of adolescent boys as shown by experimental data from the United States Public Health Service.

At this point the physiologic values of training are related, again emphazing the values chiefly to the circulatory apparatus. In protecting the adolescent boy and girl it would be well to regulate games according to age. There has been some idea that this age boy should be taking part in less highly organized games. It must be remembered that children are great imitators. Boys and girls want to imitate activities of the grown up. This is evident in all types of child play—playing house, doctor, gardner, mother, "Babe Ruth", etc. They are not content to play in doll houses with playthings that are for children. Failure to follow up this idea into adult games has been too much discouraged to the child copying adult play. If play for the child were conducted properly, the protective element physiologically would result and greater interest would attain. Children would learn to play skillfully, rather than feeling discouraged and awkward.

Why should a child play volley ball on a court worked out for adults? Why play badminton on a court and with a net worked out for adults? The paper emphasizes the importance of games played on courts and with equipment fitted to the child.

We continue to take part in activities we do well or hope to do well. We encourage skills then so that the individual will continue regular activity because knowledge and skill in some activity has been acquired. Basic changes take place during adolescence. Preparation for and guarding of adolescent youth is urgent in terms of physical activity. Let's not be so greatly concerned with stream lined trains, all-wave radio sets, air flow cars, television and the like and more concerned with sound bodies, through regulated exercise particularly during adolescence.

PAPERS IN ZOOLOGY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The program of the Zoology Section included fourteen papers and three demonstrations of which nine papers are here represented. The other five papers and the demonstration were as follows:

The Problem of Self-Fertilization Among Hermaphrodite Snails, by Clarence L. Furrow, Knox College, Galesburg.

Mastodons of the Mississippi Valley, by O. D. Thurber, Quincy High School, Quincy.

Evolution in the Habits of Lycaenid Butterflies, by W. V. Balduf, University of Illinois, Urbana.

A Study on the Migration of Birds, by T. E. Musselman, Gem City Business College, Quincy.

A Note on the Staining of the Excretory System of Trematodes (paper and demonstration), by Donald B. McMullen, Monmouth College, Monmouth.

Some Parasites of Florida Amphibia (demonstration), by A. C. Walton, Knox College, Galesburg.

Preparations of Camallanus trispinosys (Leidy) (demonstration), by Wiley W. Crawford, Blackburn College, Carlinville.

About sixty persons were present at the meeting.

George Moreland, Greenville College, Greenville, Illinois was elected chairman of the Zoology Section for the 1937 meeting.

(Signed) DONALD B. MCMULLEN, *Chairman*

Remains of Animal Life From the Kingston Kitchen Midden Site Near Peoria, Illinois

Frank Collins Baker

University of Illinois, Urbana, Illinois

The kitchen midden pits in the Illinois Valley near Kingston, fifteen miles southwest of Peoria, have yielded a large number of species of animals, both vertebrate and invertebrate. Through the kindness of Mr. A. M. Simpson of Peoria quantities of this material have been submitted for study. Studies of this kind are of value not only to the archeologist but also to the zoologist for species now rare in the locality are found to have been common at the time the Indians made the kitchen middens. Also some species may be found to have had a wider distribution previously, as in the case of the rice rat herein recorded. Some material was reported from this site in a previous paper in the Transactions of the State Academy (Vol. 23, page 231, 1931).

The invertebrates consist only of Mollusca, principally the naiades or river mussels. Twenty-one different species and races of clams and two species of snails were found in the material. Nearly all of the species are now living in the Illinois River below Peoria. This is the largest number of species of mussels reported from any kitchen midden deposit yet recorded.

The vertebrates are divided among the fishes, reptiles, birds, and mammals. Of the fish at least six species are represented, all common in the Illinois River at the present time. Of the reptiles only turtles were represented, belonging to the genera Chrysemys or Pseudemys, and Amyda. Of the birds 31 species and races are recorded, a very large number for one locality and more than twice as many as previously recorded. Among the bird groups represented are 11 ducks and geese, three hawks, and two swan. Of special note are the trumpeter swan, wild turkey, sandhill crane, and long-billed curlew, now rare in Illinois. The bones most usually preserved are the wing and the leg bones.

Of the mammals, 13 species are represented. Of special interest in this group is the beaver, now extinct in Illinois. This mammal must have been a favorite animal with the Indians for its skull or other bones are not uncommon among kitchen midden material. The otter, also, is now rare in southern Illinois and practically absent from the rest of the state. The rice field mouse (Oryzomys) is at present known only from southern Illinois and the record from near Peoria carries the former dis-

tribution well up into the middle of the state. The mammal bones preserved in these deposits consist usually of parts of the skull, leg bones, pelves, and vertebrae.

All of the species contained in the kitchen midden material is listed below. The vertebrate material was identified by specialists in the United States National Museum, and the thanks of the writer are due these specialists for their trouble in identifying such fragmentary material. The naming of the several groups should be credited to the following people:

Birds. Dr. A. Wetmore, Assistant Secretary of the Smithsonian Institution, in charge United States National Museum.
Mammals. Mr. Gerrit S. Miller, Curator of Mammals, United States National Museum.
Fishes. Dr. G. S. Myers, Assistant Curator of Fishes, United States National Museum and Mr. Earl D. Reid, Aide in the Division of Fishes of the same institution.
Turtles. Miss Doris M. Cocran, Assistant Curator of Reptiles and Batrachians, United States National Museum.
Mollusca. Frank C. Baker, University of Illinois.

The asterisk preceding a name indicates that it was listed in the previous paper published in the Transactions of the Illinois Academy of Science.

Systematic List of Species Represented

MOLLUSCA (Clams and snails)

Fusconaia undata trigona (Lea). Three left valves, adult.
Fusconaia ebenus (Lea). One right valve, adult.
*Megalonaias gigantea (Barnes). One left valve, small specimen.
Amblema rariplicata (Lamarck). Two right valves, adult. One left valve, immature.
Quadrula pustulosa (Lea). One left, one right valve, adult.
Quadrula quadrula Rafinesque. One left valve, adult.
Cyclonaias tuberculata Rafinesque. One right valve, adult.
Pleurobema pyramidatum (Lea). One left valve, half grown shell.
Pleurobema coccineum mississippiense F. C. Baker. One left valve of an adult shell does not differ from this common variety of the Mississippi River. It has not been found alive in the Illinois River near Peoria.
Plethobasus cyphyus (Rafinesque). One left valve, half grown.
*Elliptio crassidens (Lamarck). One right valve.
Elliptio dilatatus (Rafinesque). Five right and four left valves, adult.
Alasmidonta marginata truncata (B. H. Wright). One left valve, adult.
Arcidens confragosus (Say). One left valve, adult but small.
Actinonaias carinata (Barnes). Three right and three left valves, adult.
Plagiola lineolata Rafinesque. One left valve, adult.
*Proptera alata megaptera (Rafinesque). One right and one left valve, about half grown.
*Ligumia recta latissima (Rafinesque). One left valve, adult but small.
Lampsilis fallaciosa (Smith) Simpson. One right valve, small.
Lampsilis siliquoidea (Barnes). Two left valves, small.
Lampsilis ventricosa occidens (Lea). Two right valves, adult.
Campeloma rufum (Haldeman). One specimen, adult.
Pleurocera acuta lewisii (Lea). One specimen, adult.

PISCES (Fish)

*Amia calva Linn. Dogfish. Dentary, clavicle, opercle, preopercle, suborbitle.

Lepisosteus osseus (Linn.) Long-nosed gar. Dentary and interopercle.

*Ameiurus species. Bullhead. Dentary, pectoral spine, clavicle.

Micropterus species. Black bass. Interhaemal spine.

Ictiobus bubalus (Rafinesque). Small-mouth buffalo. Hypural, shoulder girdle, opercle, pelvic girdle, ribs, pectoral finrays, preopercle, interopercle, subopercle, supraclavicle, postclavicle, branchial arch, neural spine, interhaemal spine.

*Aplodinotus grunniens Rafinesque. Fresh-water drum. Interneural spine, anal spine, hypural.

Stizostedion species. Pike perch. Dentary.

REPTILIA (Turtles)

Chrysemys or Pseudemys species. Scapula, coracoid, humerus, lower jaw.
Amyda species. Humerus.

AVES (Birds)

Nycticorax hoactli (Gmelin). Black-crowned night heron. Humerus and ulna.

Botaurus lentiginosus (Montagu). American bittern. Ulna.

*Cygnus buccinator Richardson. Trumpeter swan. Humerus and ulna.

*Cygnus columbianus (Ord) Whistling swan. Metacarpus and femur.

*Branta canadensis (Linn.). Canada goose. Metacarpus and coracoid.

*Anas platyrhynchos Linn. Mallard duck. Humerus, metacarpus, tibio-tarsus.

Dafila acuta tzitzihoa (Vieillot). Pintail duck. Metacarpus.

*Nettion carolinense (Gmelin). Green-winged teal. Ulna.

*Querquedula discors (Linn.) Blue-winged teal. Coracoid, humerus, metacarpus.

Aix sponsa (Linn.) Wood duck. Humerus.

Nyroca valisineria (Wilson). Canvas-back duck. Metatarsus and metacarpus.

Nyroca affinis (Eyton). Leser scaup duck. Metacarpus.

Nyroca (affinis or collaris Don.) Caracoid and femur.

Charitonetta albeola (Linn.) Bufflehead. Metatarsus and tibio-tarsus.

Lophodytes cucullatus (Linn.) Hooded merganser. Humerus (2).

Buteo lineatus (Gmelin). Red-tailed hawk. Metacarpus.

Buteo borealis (Gmelin). Red-shouldered hawk. Metacarpus.

Buteo platypterus (Vieillot). Broad-winged hawk. Metacarpus.

Haliaeetus leucocephalus (Linn.) Bald eagle. Humerus and ulna.

*Tympanuchus cupido americanus (Reich.) Prairie chicken. Tibio-tarsus, scapula, metacarpus, ulna.

Colinus virginianus (Linn.) Bobwhite. Humerus and femur.

*Meleagris gallopavo silvestris (Vieillot). Wild turkey. Humerus, femur, metacarpus, coracoid, tarso-metatarsus, ulna, and tibio-tarsus.

Grus canadensis (Linn.) Sandhill crane. Part of ulna.

Porzana carolina (Linn.) Carolina rail. Tibio-tarsus and furcula.

Fulica americana Gmelin. Coot. Metacarpus and tibio-tarsus.

Numenius americanus Bechstein. Long-billed curlew. Ulna.

Philohela minor (Gmelin). Woodcock. Tibio-tarsus.

Limnodromus griseus (Gmelin). Dowitcher. Humerus.

Colaptes auratus luteus Bangs. Flicker. Ulna.

Agelaius phoeniceus (Linn.) Red-winged blackbird. Humerus.

Quiscalus quiscala (Linn.) Grackle. Ulna.

MAMMALIA (Mammals)

*Odocoileus virginianus (Bodd.). Virginia deer. Teeth, part of skull, part of lower jaw, heel and toe bones, vertebrae.

Sciurus niger rufiventer (Geoffroy). Fox squirrel. Humerus, radius, tibia, ramus of lower jaw.

*Sciurus carolinensis Gmelin. Gray squirrel. Humerus.

*Castor canadensis Kuhl. Beaver. Pelvis, humerus, radius, tibia, fibula, ulna, rib, vertebrae.

*Ondatra zibethica (Linn.) Muskrat. Part of skull and lower jaw, pelvis, sternum, humerus, femur, tibia-fibula.

*Mustela vison luteocephalus (Harlan). Mink. Skull and lower jaw, femur, humerus, ulna, foot bones.

Lutra canadensis (Schreber). Otter. Skull.

Procyon lotor (Linn.) Raccoon. Left ramus of jaw, radius.

Lynx rufus (Guldenstaedt). Wild cat. Bob cat. Humerus.

*Canis familiaris Linn. Skull and jaws, scapula, part of pelvis, femur, humerus, ulna, radius, tibia, rib, toe, bones, atlas.

Scalopus aquaticus cf machrinus (Raf.) Prairie mole. Jaw, tibia.

Sylvilagus floridanus mearnsii (Allen). Mearn's cotton-tail rabbit. Lower jaw, scapula.

Oryzomys palustris (Harlan). Rice field mouse. Femur, tibia-fibula, skull.

Notes on *Stephanoprora polycestus* (Dietz) From the American Crow

Paul Beaver

Oak Park Junior College, Oak Park, Illinois

In March, 1934, three crows *(Corvus brachyrhynchos brachyrhynchos)* were received from Havana, Illinois. They had been taken in a cage trap and were fed "fish" for several days before they came into my hands through the kindness of Dr. David H. Thompson and other members of the research staff of the Illinois State Natural History Survey. Trematode ova were found in the feces of each crow on the third day after they were received which was roughly two weeks after their capture and first feeding of fish. Three weeks later, 19, 19, and 6 specimens of *Stephanoprora polycestus* Dietz, 1909 were taken from the middle ileum of each of them respectively. Since each carried the same species of worm and the specimens were in the same stage of development (all mature and very uniform in size) it is possible that all became infected at the same time, from the same source, and therefore from the fish on which they were fed.

Although there are but a few points on which my observations differ from previous descriptions of *S. polycestus*, a brief description is added to the report of its incidence. Body length, 4.4 to 4.8 mm; length 10 X greatest width at level of anterior testis. Measurements in microns on an average specimen 4.8 mm long are: width of collar, 249; diameter of acetabulum, 275; oral sucker, 146 by 130; pharynx, 144 by 118; ovary, 130 by 100; anterior and posterior testes respectively, 378 by 283 and 522 by 193; ova, 52 by 84 to 58 by 80. In all specimens, body length 8.28 to 6.60 X pre-acetabular region, 2 to 2.2 X post-testicular region and 11.2 to 12.6 X the region between acetabulum and ovary. Rather stout cuticular spines, 12 to 16 μ in length, are restricted to the pre-acetabular region dorsally but reach to the anterior testis ventrally. The mid-ventral pre-acetabular area is without cuticular spines. There are 22 cephalic spines of nearly equal size arranged into right and left rows separated dorsally and ventrally by a space about equal to the width of the oral sucker. The two posteriormost spines on each side are smaller than, and are distinctly aboral or posterior to the 9 remaining ones (Fig. 2, 3). The largest cephalic spine is 40 to 42 μ by 12 to 14 μ. The uterus is of moderate length and contains from 40 to 75 ova. The length of the cirrus sac is roughly equal to the diameter of the acetabulum and reaches to about the center of that organ (Fig. 1). In good preparations this species may be seen to possess a uroproct. This structure is partially covered by the vitellaria, which probably accounts for the fact that it has not been observed previously in this species (Fig. 1, 4).

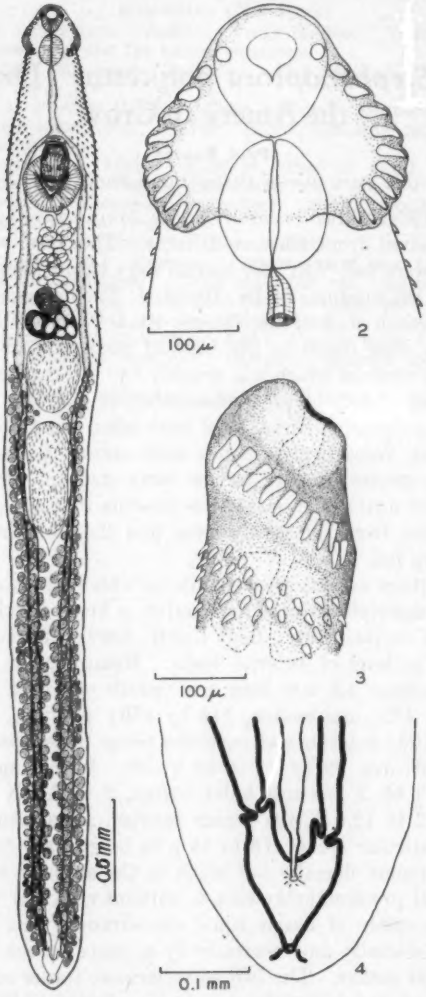

Fig. 1.—*Stephanoprora polycestus.* VENTRAL VIEW OF TYPICAL SPECIMEN FROM THE CROW. CAMERA LUCIDA DRAWING.

Fig. 2.—HEAD CROWN. VENTRAL VIEW. CAMERA LUCIDA DRAWING OF CLEARED SPECIMEN.

Fig. 3.—HEAD CROWN. LATERAL VIEW. CAMERA LUCIDA DRAWING OF OPAQUE SPECIMEN.

Fig. 4.—POSTERIOR END SHOWING CONNECTIONS OF EXCRETORY BLADDER AND INTESTINAL CECA WITH UROPROCT.

Discussion.—There are ten or less valid species of echinostomes that belong to the genus *Stephanoprora* Odhner, 1902 (= *Mesorchis*, Dietz, 1909 = *Monilifer* Dietz, 1909 nec *Mesorchis* Linton, 1910) as it was originally described (Odhner, 1902, 1910). One finds in the literature several other species that might cause some confusion with the true members of this genus. *Mesorchis urna* Linton, for example is a member of the Allocreadiinae, Linton's genus *Mesorchis* being created independent of the genus *Mesorchis* Dietz, 1909 (= *Stephanoprora* Odhner, 1902); *Monilfier pitangi* Lutz, 1924 is taxonomically misplaced, it being a member of the genus *Echinochasmus* Dietz, 1909; and *S. anomala* Travassos, 1922 is too imperfectly known to allow systematic treatment. As a result of a study of the variability to be observed in specimens of *S. denticulatus* (Rud., 1802) from various hosts from different regions Odhner (1910) was led to regard *Ech. pseudoechinatum* (Olss., 1876), *Mesorchis polycestus* Dietz, 1909 and (?) *Ech. spinulosum* (Rud. nec Dietz) as synonyms of *S. denticulatus*, and he also regarded *Monilifer spinulosus* Dietz, 1909 (nec Rud.) as a synonym of *S. spinosa* Odhner, 1910, it being necessary to create the new name because *"spinulosa"* was preoccupied. My own study of this group as well as an earlier study (Beaver, 1936) of the genus *Echinostoma* leads me into agreement with Odhner on all species excepting *S. polycestus*. I regard it as distinct from *S. denticulatus* because of its more anteriorly disposed vitellaria, more extensive uterus and relatively smaller suckers and head crown. *S. gilberti* Ward, 1917, which was reported and briefly described by Gilbert (1905) as *Ech. spinulosum* and renamed by Ward (1917, 1918) is apparently identical with *S. spinosa* Odhner. Although I regard *S. polycestus* as a valid species I am inclined to disregard the one point of description on which it may be considered to disagree with the worms described above from the crow. In both text and figure (Dietz, 1910, p. 453, Textfig. M^2) its cephalic spines are represented as having distinctly flat bases. All of the related species have bluntly rounded bases which sometimes appear to be nearly flat. I am doubtful if this can be a real difference. *S. reynoldi* Bhalerao, 1926 and *S. merulae* Yamaguti, 1933 are doubtless both identical with *S. polycestus*. The author of the first mentioned separated it from *S. polycestus* because of very slight differences in the ratio of the suckers and position of the cirrus sac, both of which are variable within limits which are quite unavoidable even when uniform methods of fixation are used. Egg size, length of spines, and extent of the vitellaria were regarded as unique in *S. merulae*. There is a difference of only 6 to 9 microns in the size of the eggs in the three species (*merulae, reynoldi, polycestus*). The spines of each are about equal in size when compared with the size of the worm, the longest being about one one-hundredth the total length of the body in each. The vitellaria in each reaches well up along the sides of the anterior testis. *S. merulae* and *S. reynoldi* were each described from single specimens that were fairly immature, having just begun egg

formation. *S. denticulatoides* Isaitschikow, 1924 from the dog is apparently also identical with *S. polycestus,* although it is somewhat smaller. Its maximum length is only 4.2 mm.

It is therefore probable that the nine species included in the following key constitute the only valid species of the genus *Stephanoprora;* and the worms described above from the crow, *Corvus b. brachyrhynchos,* are North American representatives of the species *S. polycestus.*

KEY TO THE SPECIES OF THE GENUS STEPHANOPRORA ODHNER, 1902
(= Mesorchis, Monilifer)

1.	(2)	Cephalic spines 26 in number	**ornata** Odhner, 1902
2.	(3)	Cephalic spines 24 in number	**ozakii** (Asada, 1926)
3.	(1,2)	Cephalic spines 22 in number	4
4.	(11)	Vitellaria distinctly posterior to junction of testes	5
5.	(6)	Acetabulum wider than body proper	**singularis** (Lutz, 1924)
6.	(5)	Acetabulum not wider than body proper	7
7.	(10)	Angle spines distinct from border spines	8
8.	(9)	Vitellaria extend to middle of posterior testis	**denticulatus** (Rud., 1802)
9.	(7)	Vitellaria confined to post-testicular region	**microtestius** (Kurova, 1927)
10.	(4)	Angle spines not distinct from border spines	**pendula** (Looss, 1899)
11.	(3)	Vitellaria at junction of testes or more anterior	12
12.	(15)	Uterus very short, being less than length of region of body anterior to genital pore	13
13.	(14)	Body stout; testes large, occupying ¼ to ½ of hind-body	**spinosa** Odhner, 1911
14.	(12)	Body slender; testes occupying less than ¼ of hind-body	**conciliata** (Dietz, 1909)
15.	(11)	Uterus of medium length, being greater in length than the region of body anterior to genital pore	**polycestus** (Dietz, 1909)

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The Illinois Species of *Brachymeria* (Hymenoptera, Chalcididae)

B. D. Burks

Illinois State Natural History Survey, Urbana, Illinois

The genus *Brachymeria* Westwood includes a number of primary and secondary parasites often encountered in rearing Lepidoptera and cyclorrhaphous Diptera. *Brachymeria* has usually been treated as the genus *Chalcis;* the hind coxae are elongate and round in cross-section, the hind femora are enlarged and provided with a row of teeth on the lower side, the hind tibiae are arcuate and have a single apical spur, the abdomen is sessile, and the antennae are inserted above the lower margins of the compound eyes. The body is black, but the hind femora are usually colored in part yellow or red.

In the following table of the Illinois species, it is to be noted that the apparent first abdominal segment is actually the third; the malar ridge is a carina running parallel with the fronto-genal suture of the head; the inner tooth of the hind femur is a small projection, ventro-proximad, on the ental surface. All statements regarding color should be taken loosely. In order to verify identifications it is frequently necessary to examine the internal genitalia of the male. In the drawings given of these genitalia, figures 10-14, only the oedagus is shown, the inner and outer sheaths and sagittae being omitted. The sagittae are too variable to be useful for the separation of species.

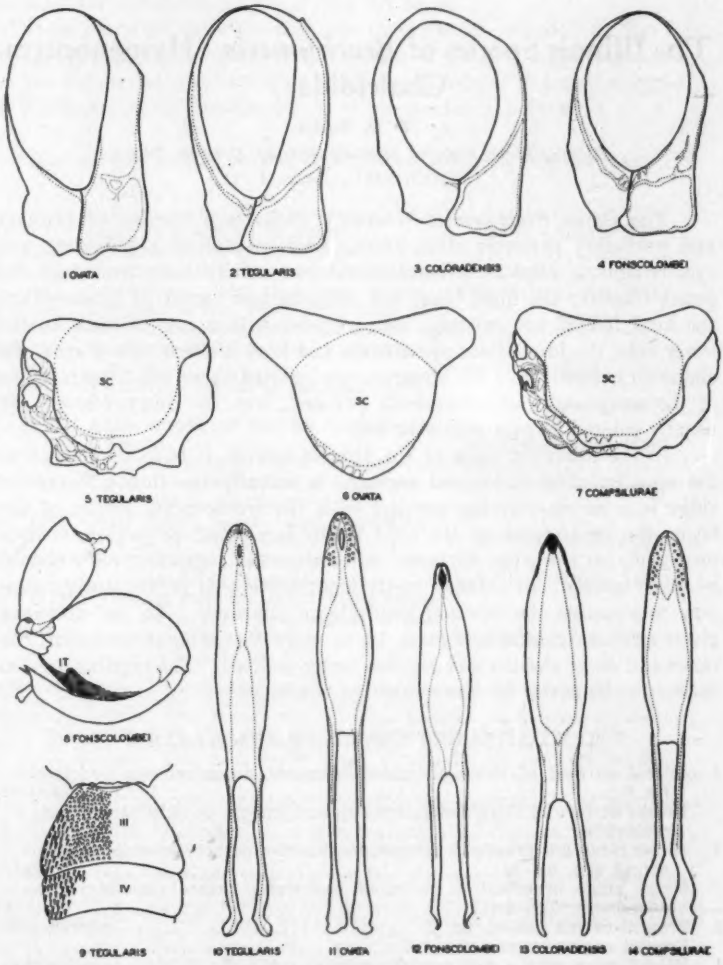
KEY TO ILLINOIS SPECIES OF *BRACHYMERIA*

1. Dorsal surface of third abdominal segment conspicuously punctate, fig. 9 ..... *tegularis*
   Dorsal surface of third abdominal segment smooth or only very faintly reticulated 2
2. Malar ridge not branched or deflected backwards before reaching compound eye, fig. 1 ..... *ovata*
   Malar ridge branched or deflected backwards before reaching compound eye, figs. 2-4 3
3. Frontal carina absent, fig. 3 ..... *coloradensis*
   Frontal carina present, fig. 4 4
4. Hind femora with a distinct, sharp inner tooth, fig. 8 ..... *fonscolombei*
   Hind femora without an inner tooth ..... *compsilurae*

Brachymeria tegularis (Cresson) *new combination*

Chalcis tegularis Cresson, *Trans. Am. Ent. Soc.*, 4:60, 1872. Type, number 1825, Philadelphia Academy of Natural Sciences, ♀.

This species is more common west of the Mississippi than in Illinois. The hind femora of the female are almost entirely yellow. The male has not before been described.



EXPLANATION OF PLATE

Figs. 1-4. Lateral aspect of the head, mouth parts omitted.
Figs. 5-7. Dorsal aspect of the scutellum (SC).
Fig. 8. Ental aspect of the hind femur, IT, inner tooth.
Fig. 9. Dorsal aspect of the third and fourth abdominal segments.
Figs. 10-14. Male genitalia.

Male.—Diagnostic characters as in female. Hind femora black with an apical and a small dorsal yellow spot. Malar ridge branched, fig. 2, scutellum bidentate, fig. 5. Oedagus as in fig. 10.

Allotype.—Male; Zion, Ill., July 6, 1932, T. H. Frison et al. Deposited in the collection of the Illinois State Natural History Survey.

Algonquin: Aug. 1, 1895, 1♂. Champaign: July 30, 1891, 1♀. Dayton: July 18, 1879, 1♂. Normal, 1877, 1♂. Urbana: Sept. 1, 1886, 1♀. Zion: July 6, 1932, 1♂.

Brachymeria ovata (Say)

Chalcis ovata Say, *Long's Second Expedition*, 2:326, 1824.

The type of this species is lost, but some of the material on which Cresson (1872) based his redescription has been seen in the Philadelphia Academy of Natural Sciences. This species has been synonymized with *flavipes* Fabr., but Dr. Olaw Schröder of the Kiel Museum has kindly compared specimens of *ovata* with the Fabrician type of *flavipes* and states that they are not the same species.

This is by far the most common Illinois species of *Brachymeria*. The malar ridge is unbranched, the scutellum is not bidentate, fig. 6, the antennal scape is longer than in most other species, and there is a single, somewhat irregular row of setae near the anterior margin of the dorsum of the fourth abdominal segment. The hind femora of both the male and female are black with an apical yellow (or red) spot. The male genitalia are shown in fig. 11. This species is a primary parasite of Lepidopterous pupae.

Common throughout the state from June to October; taken in hibernation as an adult. The following material has been reared: Normal: July 8, 1905, from Strawberry leaf-roller, 1♂. Springfield: Sept. 17, 1909, from Bag Worm, 1♀. Urbana: Sept. 10, 1900, from Bag Worm, 1♀; July 6, 1922, from Celery Leaf-tyer, 1♂, 1♀; July 25, 1924, from Tussock Moth, 1♂, 1♀; July 26, 1924, from Tussock Moth, 1♂; Oct. 30, 1935, from Fall Web-worm, 1♀; July, 1936, from Tussock Moth, 5♂, 4♀.

Brachymeria coloradensis (Cresson) ***new combination***

Chalcis coloradensis Cresson, *Trans. Am. Ent. Soc.*, 4:60, 1872. **Type, number 1826, Philadelphia Academy of Natural Sciences, ♀.**

Chalcis dalmanii Thomson, *Hymen. Skand.*, 4:17, 1875. *New synonymy.*

Mr. A. B. Gahan of the U. S. National Museum suggested that *dalmanii* and *coloradensis* might be the same species, and paratypes of the former, kindly loaned for study by Dr. Rene Malaise of the Stockholm Museum, have proven identical with the type of Cresson's species. This species is a secondary parasite of grasshoppers, having been reared by Kelly (1914) in America, Vinokurow (1927) in Eastern Siberia, Olsuf'er (1929) in Russia, and Rukavishnikov (1930) in Turkestan.

The hind femora of the female are red with an apical yellow spot; in the male they are black with the apex red or yellow, or both. The malar ridge is directed backwards before reaching the compound eye, and the scutellum is emarginate. The male genitalia are shown in fig. 12.

Havana: June 23, 1926, 1♂. Mason City: June 21, 1926, 2♂, 1♀. St. Anne: Aug. 4, 1936, 4♂, 2♀.

Brachymeria fonscolombei (Dufour)

Chalcis fonscolombei Dufour, *Ann. Soc. Ent. Fr., 10*:11, 1841. Lectotype ♂ and Lectoallotype ♀ in the Dufour collection, Muséum National d'Histoire Naturelle, Paris. *Present designation.*

M. Lucien Berland has kindly compared specimens with the type series in the Dufour collection, and found the specimens sent to be identical with part of the type series; as this series also includes a specimen of *coloradensis*, lectotypes have been designated for *fonscolombei*.

This is a holarctic species, a primary parasite of blow flies. A life history has been published by Roberts (1933). The hind femora of both the male and female are red with an apical yellow spot. The malar ridge is branched, and the scutellum is bidentate or emarginate at the apex. The male genitalia are shown in fig. 13.

Urbana: Oct. 5, 1925, 1♀.

Brachymeria compsilurae (Crawford)

Chalcis compsilurae Crawford, *Proc. U. S. Nat. Mus., 41*:272,1911. Type, 13802, United States National Museum, ♀.

This species occurs in the north central states and New England; it is a secondary parasite of Lepidoptera. A life history has been published by Dowden (1935). The malar ridge is branched, the scutellum is emarginate, fig. 7, and the basal tooth of the hind femur is larger than the others. The hind femora are black with an apical yellow spot in both sexes. The male genitalia are shown in fig. 13.

Algonquin: 1♀. Champaign: May 25, 1890, 1♀. Oregon: Aug. 23, 1935, 1♀. Urbana: Brownfield Woods, July 25, 1924, 1♂; University Woods, July 24, 1934, 1 ♀; July 12, 1935, 1♀.

Descriptions of Two Larval Nematodes of Family Camallanidae Found in Damselfly Naiads, (*Enallagma* sp.)

W. W. Crawford

Blackburn College, Carlinville, Illinois

The two larval nematodes described in this paper were found in the stomach of damselfly naiads (*Enallagma* sp.), collected from Glenwood Lake near Minneapolis, Minnesota, on April 25, 1933. Of the 11 naiads that were collected at this time and examined for parasites only 2 were infested, each with 2 immature worms. One specimen from each host was successfully mounted for future study and they are described as follows:

Specimen One from first host: Body tapering gradually posteriorly, 2.16 mm. long by .08 mm. broad. Mouth prominent and equipped with two conspicuous yellow scallop-shaped valves .06 mm. long by .05 mm. broad. Each valve is marked with 10 or more longitudinal lines. Anus .12 mm. in front of caudal tip which bears a single minute spine. Esophagus bipartite. Anterior esophagus muscular and club-shaped, .2 mm. long by .04 mm. broad. Posterior esophagus granular and cylindroid, same size as preceding. Intestine 1.7 mm. long. Reproductive organs obscure or undeveloped.

Specimen Two from second host: Body 2.40 mm. long and .09 mm. broad. Anus .3 mm. from the caudal tip which bears 3 minute spines. Mouth and esophagus same as in the preceding specimen. Anterior esophagus .24 mm. long and .05 mm. broad. Posterior approximately same size. Intestine 1.5 mm. long. Reproductive organs obscure or undeveloped.

The presence of the characteristic heavy oral armature readily identifies these worms with the family Camallanidae. In the absence of feeding experiments it is difficult to be certain about the more specific taxonomic relationships. However, the presence of the three minute caudal spines in the second specimen indicates that it is a female and may be identical with the form described by Leidy (1853) as *Camallanus trispinosus.*[1] If this is true the first specimen is a male as the males of this species lack the spines.

In view of the scarcity of knowledge concerning the early development of the Camallanidae in general, this discovery may lead to the extension of such information.

Turtles of the genus *Emys,* known to be the host of *Camallanus trispinosus,* were observed in the same lake in the vicinity where the infested nymphs were collected.

[1] Diesing (1851) recognized *trispinosus* as a synonym of *microcephalus* (Duj. 1845) and Leidy subsequently followed him in this usage.

The Effect of Winter Temperatures of 1935-1936 on Some of the Common Illinois Insects

W. P. Flint

State Natural History Survey, University of Illinois Agricultural Experiment Station, Urbana, Illinois

The winter of 1935-36 established a record in the state for long periods of low temperatures. According to statements given in the Climatological Data sheet put out by the U. S. Department of Agriculture Weather Bureau, Illinois section, January 1936 was one of the coldest January's on record, with a minimum temperature at Freeport in Stephenson county of -27 degrees F. on January 23rd.

February was equally cold and quoting from this publication: "This was not only the coldest February since 1905, but disregarding calendar month divisions and taking the 31 day period from January 22d to February 21st a mean temperature of approximately 8.3 degrees is obtained, which is 4.3 degrees lower than the extremely cold calendar month record of January, 1917. Considering the entire winter, December to February, inclusive, State averages dating back to 1878 show only the winters of 1880-81, 1884-85, and 1917-18, to have been colder. While more severe extreme temperatures have previously prevailed over the State, frequency of zero-weather this winter exceeds that of any winter since 1884-85. Presenting the cold picture in another way, extreme north-western Illinois from January 19th to February 22d. had only four days free of zero readings, Chicago had 273 hours of zero weather, Peoria 312 hours, Springfield 168 hours, and zero readings were quite general in the southern division on 10 days."

Throughout the northern two-thirds of the state there were many days of sub-zero temperature recorded at all stations. In the northern division minimums of -66 to -21 occurred at many stations in January and about the same temperatures were recorded during two different periods in February.

In the southern division minimums were as usual higher, the January minimums for the section from Carbondale south being from -1 to -7, and the February minimum from -7 to -10. In this part of the state the cold periods were of much shorter duration. Such unusually cold weather, extending as it did over practically a 31-day period, could not help but have a marked effect on some of the hibernating insects that normally occur in this state.

During the past two months attempts to check the effect of these low temperatures on some of the more important economic species have been made. In southern Illinois Mr. S. C. Chandler, Southern Illinois

Field Entomologist, Illinois State Natural History Survey, made numerous examinations of codling moth and Oriental fruit moth larvae. For points north of Carbondale his examinations showed approximately 52 per cent of the codling moth dead. In Greene County, however, which was the most northern point covered by his examinations, 64.5 per cent of the codling moth were dead.

Of the Oriental fruit moth, 100 per cent of the larvae hibernating in cocoons on the trunks of the trees or at other points above the snow line were killed at all points where examinations were made north of Jackson, Union and Johnson counties. In Jackson County from 20 to 33 per cent of the larvae were dead and about 20 per cent were dead in Johnson County.

Our examinations in the vicinity of Urbana failed to show any living codling moth above the snow line.

San Jose scale was unusually abundant in the Fall of 1935, the warm October permitting a late development of this insect. Two weeks after the first period of sub-zero temperatures, attempts were made to determine the per cent of mortality of this scale. At this time, however, the scale was found still in a plump condition and the usual examinations made by removing the waxy scale covering from the insect did not show conclusively whether the scale was alive or dead. Three weeks later another examination was started and by this time, due to a period of warm weather, it was very easy to distinguish the dead from the living scale. A large number of samples of scale from different orchards in the southern and central parts of the state were examined during March. These examinations showed from Centralia north better than 99 per cent of the scale had been killed, the actual figures showing only 0.3 of 1 per cent of the scale alive as the average for this area of the state.

From Centralia to Carbondale between 2 to 3 per cent of the scale remained alive. In Jackson County, approximately 4 per cent of the scale was alive. In Saline County about 7 per cent survived. In Gallatin County 19 per cent were alive.

In the extreme southern part of the state in Union, Massac and Johnson counties, the per cent of scale alive was 12, 10 and 16 per cent respectively.

There was, as was expected, a considerable variation in samples in this southern area, some samples showing only 1 or 2 per cent of the scale alive while others showed as high as 22 per cent of the scale alive. In cases where the San Jose scale was protected by a covering of snow around the base of the trunks of young trees, a much higher per cent of scale survived. In Pike County, for instance, we examined one sample of scale taken from under the snow cover about the base of young trees. This sample showed 35 per cent of the scale alive. Three samples taken from the same general area but not below the snow line showed 99 + per cent dead, the actual figures being 1 scale alive out of 1,300 examined.

The Oyster Shell Scale, which passes the winter in the egg stage instead of in the partly grown nymphal stage, showed only a very slight mortality from cold weather. Samples of this scale taken from central Illinois which have been hatched in the laboratory have given no more than the normal per cent of winter kill.

Tussock moth eggs and aphid eggs were not injured by the cold weather. Aphid eggs in general have shown a normal hatch in the early Spring of 1936.

In Northern Illinois, where the European elm scale has become abundant, it was hoped that the temperatures of -25 to -27 might have destroyed at least a part of the overwintering, immature scale of this species. Our examinations, however, show this was not the case. Of the samples so far examined less than 10 per cent had died during the winter. This is little if any higher than the normal winter mortality. It seems unusual that this scale should survive so well when the San Jose scale in the same area was almost completely killed out.

There was no great kill of insects that hibernate on the surface of the ground and which are protected more or less by snow during the periods of lowest temperatures.

Mr. J. H. Bigger, Western Illinois Field Entomologist, Illinois Natural History Survey, has made a number of examinations of chinch bugs and finds the winter mortality running about 15 to 20 per cent. Figures from our examinations in the eastern part of the state showed about the same mortality. Where the bugs were hibernating in clumps of grass that were exposed to the full force of the wind and were clean of snow, the mortality would run very high, in some cases over 90 per cent. As a rule, the chinch bug does not choose hibernating quarters of this type and in many of the protected areas the mortality was less than 5 per cent.

Of the other field crop insects of particular importance, Hessian fly suffered a mortality of possibly 30 to 40 per cent although where protected by snow not more than 10 per cent of the overwintering flies were killed.

Cutworms and flea beetles survived the low temperatures without any particular harm. So far as we have been able to tell the continued low temperatures and deep freezing of the ground, did not have any effect on larvae that normally hibernate beneath the surface soil, such as the white grub.

Summing up the results of our examinations to date, the abnormally cold weather had the effect of greatly reducing San Jose scale and brought about a considerable reduction of codling moth and a marked reduction of Oriental fruit moth. They had little or no effect in reducing the numbers of any of the other injurious insects on which it has been possible to make any definite check.

Studies on the Lymnaeid Snail, *Fossaria parva* (Lea).

Part I: Winter Habits

C. Clayton Hoff
Peoria Heights, Illinois

During the winter of 1934-1935, the writer made monthly collections of the Lymnaeid Snail, *Fossaria parva* (Lea) for the purpose of studying the life history. Information relating to the winter habits was also gathered during twenty-six field trips in the period between December 18, 1934, and May 16, 1935, and six trips from November, 1935, to March, 1936.

Collections of *Fossaria parva* were made from an intermittent stream which has a maximum depth of about twelve inches and a maximum width of two feet. Clear, cool surface water fills the stream from the middle of November until the last of June. At times of excessive rain, the stream may spread over the bottoms which are 50-75 feet wide. The discharge, however, is so rapid that the bottoms are inundated for only short periods. The stream is located in what was formerly a meadow at Peoria Heights, Illinois.

The molluscan fauna of the stream consists of a single species, *Fossaria parva*. The only other aquatic mollusc in the vicinity is *Physa halei* which is found in large numbers in an artificial pond located out of the bottom area, about fifty feet from the stream, and at an elevation of about eight feet higher. Although the overflow from this vernal autumnal pond runs into the stream, it is a significant fact that no *Physa halei* have been taken from the stream.

The margins of this stream furnish a characteristic habitat for *Fossaria parva* which is said to inhabit wet, marshy places, generally out of the water on sticks, stones, or muddy flats (Baker, 1928, p. 287). In the specific locality in which the study was made, this statement applies during certain months of the year; but the writer has found that *Fossaria parva* lives almost entirely in the water from December to March of each year. This fact apparently does not contradict the statements of other writers, but rather illustrates a definite lack of information regarding the winter habits of the species.

The presence of *Fossaria parva* in this locality was first discovered on December 18, 1934, when several snails crawled up the sides of a jar containing bottom material from the stream. In the autumn of 1935, the snails were observed in the stream during the first week in December. At that time, water had been flowing in the stream for only ten days,

as the stream had been dry since July 1, 1935. Early in December, the snails were found in the quiet, shallow areas of the stream but as ice began to form permanently on the surface of the water, each increase in the extent and thickness of the ice caused a migration of the snails to deeper water where there was no danger of being frozen in the ice. During periods of partial thaw, the ice receded and the snails returned to more shallow water.

Throughout January, in both 1935 and 1936, snails were collected through holes chopped in the ice which covered the stream and in severe weather stopped the flow of water. The snails were found only in the quiet, deep pools where there was a layer of water under as much as six to eight inches of ice. Snails have been taken from bottom mud in pools whose surfaces have been continuously frozen for a month. During the periods of ice cover, the water is far from being devoid of oxygen because of the development of dense growths of the filamentuous alga, *Schizomeris*. Being rather inactive and requiring small amounts of oxygen, it is possible that the oxygen required by the snails is absorbed directly by the bodies of the animals.

It is evident, during the months of January, February, and part of March, that *Fossaria parva* feeds very little if at all. This statement is the result of the observation of the following facts: (1) Collections of the buoyant, bottom-anchored *Schizomeris* showed that very few of the snails inhabited the algal growths but they were found beneath the growths on the bottom mud. This would indicate that the filamentuous alga was not being used as food. Examination of the bottom mud indicated a lack of food until the last of March, where there was a development of uni-cellular forms such as diatoms and *Euglena*. (2) Examination of the alimentary canal of snails taken during the period showed no indication of recent feeding and no snails collected during January and February voided feces after their capture. (3) Studies of size distribution of individuals of the monthly collections show that there was little growth. The mean and the median of the individual collections showed an increase of 0.3 mm and 0.27 mm respectively between the January 6-7 collection and the March 8-10 collection in 1935. As the distribution curves in both cases are uni-modal and there was no increase in population due to birth or decrease due to natural death, it is evident that actual growth is indicated by the progress of the arithmetic mean and the median. As snails 8 mm in length are very common during certain months, it is clear that a growth of only 0.3 mm in two months is very small in comparison with the growth which takes place during more favorable seasons of the year.

Associated with *Fossaria parva* during December, January and February are the invertebrates characteristic of the intermittent stream. These include copepods, *Planaria*, and the larvae of the caddis-, horse-, soldier-, and midge-fly. The nymph of the stone-fly, *Perla*, is also

found. It is not until the second week in March that collections include the Isopod, *Asellus*.

During the year 1935, the first week in March marked a radical change in the physical condition of the stream. The corresponding change occurred, during 1936, in the last week of February. At this time, most of the ice disappeared from the stream except in the quiet pools and along the shore. Collections made on the 8th and 10th of March, 1935, showed that *Fossaria parva* was no longer found in the deep pools but had migrated to the more shallow areas. Here the snails remained, evidently feeding to some extent, until the warm days of late March when they were seen along the edges of the stream out of the water. They are never found out of the water, however, unless the water is free from ice and the atmospheric temperature is 40 degrees Fahr. or above. A change in the temperature of the air to less than 40 degrees appears to furnish the stimulus required for a return to the water. After cool nights, especially when a thin sheet of ice has been frozen along the shore, the snails will be found in the shallow water immediately under the layer of ice. As the ice melts under the action of the sun, the snails migrate from the water, only to return again when the nocturnal temperature falls below 40 degrees. This migration from water to land and back again is often a daily occurrence during the last two weeks of March and most of April.

As a check on field observations, experiments were performed to demonstrate the reaction of *Fossaria parva* to changes in temperature. Snails taken with bottom material in March and placed in jars at room temperature crawled out of the water and up the sides of the jars. When these containers were placed in a refrigerator, the snails returned to the water. At another time, fifteen snails, including both mature and juvenile individuals, were picked from mud flats during June and placed in shallow water in a large beaker cover. In less than one-half hour, all of the snails had crawled out of the water. The cover was then quietly removed from room temperature and placed directly on ice in a refrigerator. In less than three-fourths of an hour, all of the snails had crawled back into the water. The cover was then removed to room temperature and the experiment twice repeated with the same individuals. During the last repetition, many of the snails became moribund, evidently as a result of the rough treatment received by the radical and sudden changes in temperature.

As a result of heavy rains, a flood occurred on May 1-2, 1935, and the snails were scattered over a considerable portion of the flood plain. On May 12, the stream was well within its banks and the bottom was examined for the presence of snails. It was found that the occurrence of snails in the water was very rare and that they were concentrated about a foot from the water, on muddy flats consisting of silt carried in by the flood. These flats were small areas of one to two square feet, isolated by strips of grass, and between six and twelve inches above the

surface of the stream. In damp weather, snails could be found on such areas as far as ten feet from the stream. The snails apparently avoid vertical banks or areas with a slope greater than thirty degrees. After the middle of May, the snails remain, almost without a single exception, on these bare, muddy flats.

It is obvious that the winter aquatic habitat of *Fossaria parva* is of distinct advantage to the species, especially since the individuals found during the winter are immature and of a small size. Such a protective measure is in direct contrast to the condition found in the closely related species, *Fossaria modicella,* as observed by VanCleave (1935, p. 103) who states that there was no evident tendency for *Fossaria modicella* (living on vertical sandstone cliffs in Turkey Run State Park) to seek shelter during the winter. Such a contrasting condition which exists between two related, often confused (Baker, 1911, p. 245) species might offer another character for specific distinction between the habits of the two snails. Such a general statement, however, must not be made until there are further investigations of the species from other localities.

The writer wishes to thank Mr. F. C. Baker for determining the identity of *Fossaria parva* and *Physa halei* from specimens submitted to him and T. Dale Foster and Dr. H. J. VanCleave for many helpful suggestions.

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The Nearctic Sawflies of the Genus *Fenusa* (Hymenoptera, Tenthredinidae)

Herbert H. Ross

Illinois State Natural History Survey, Urbana, Illinois

The sawflies of this genus are leaf-miners so far as known, as follows: *ulmi* on elm, *pusilla* on birch, *dohrnii* and perhaps *inspiratus* on alder. They have been in considerable taxonomic confusion and this brief synopsis has been prepared in an effort to straighten matters out. A key is given for the recognition of the species, together with illustrations of the genitalia, which are essential for checking identifications. The species are all small, less than four millimetres in length, and are mostly black.

Types designated in this paper are deposited in the collection of the Illinois State Natural History Survey except where noted.

KEY TO NEARCTIC SPECIES

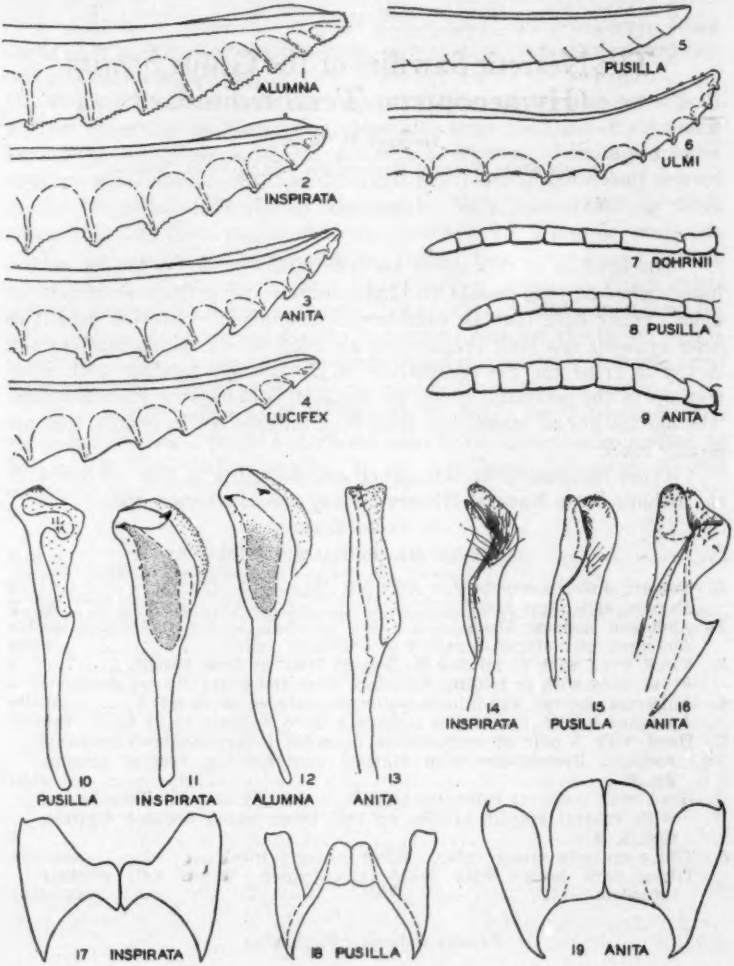
1. Femora and coxae yellow 2
   Femora and coxae black 3
2. Abdomen entirely black ..... *lucifex*
   Abdomen with sternites yellow or brownish yellow ..... *anita*
3. Front wing with 2*r* joining R_5 beyond 3*r-m*, or 3*r-m* absent 4
   Front wing with 2*r* joining R_5 before 3*r-m*, the latter always present .. 5
4. Antennae shorter, the middle segments reduced as in fig. 8 ..... *pusilla*
   Antennae longer, the middle segments more elongate as in fig. 7 .. *dohrnii*
5. Head with a pair of conspicuous diagonal tubercles above antennal sockets. Female saw with digitate processes on ventral margin, fig. 6 ..... *ulmi*
   Head with diagonal tubercles almost or entirely absent. Female saw with ventral margin broken up into lobes which are not digitate, figs. 1, 2 6
6. Tibiae entirely cream color. Wing strongly infuscate ..... *alumna*
   Tibiae dark brown with their apices paler. Wings only slightly infuscate ..... *inspiratus*

Fenusa dohrnii (Tischbein)

Kaliosysphinga dohrnii Tischbein, Stetting. ent. Zeitg., vol. 7, 1846, p. 80.

Fenusa curtus Norton, Proc. Ent. Soc. Phil., vol. 1, 1861, p. 199, ♀. *New synonymy.*

A true holarctic species which is usually but erroneously considered introduced. Nearctic records: B. C., Colo., Mass., Me., Mich., Ont., Sask.



EXPLANATION OF PLATE

Figs. 1-6.—Apices of saws.
Figs. 7-9.—Antennae.
Figs. 10-13.—Penis valves.
Figs. 14-16.—Sagittae and volsellae.
Figs. 17-19.—Parapenes and gonostipes.

Fenusa pusillus (Lepeletier)

Tenthredo (Emphytus) pumila Klug, Magaz. Ges. naturf. Fr. Berlin, vol. 8, 1814, p. 277. Preoccuppied.
Dolerus (Fenusa?) pusillus Lepeletier, Monogr. Tenthred., 1823, p. 120.

Klug described two species *Tenthredo (Allantus) pumila* and *Tenthredo (Emphytus) pumila* in the same genus. The former is now known as *Entodecta pumila*, but the latter is obviously a direct homonym and Lepeletier's name *pusilla* must be used instead.

A European species which has probably been introduced into North America. Nearctic records: Mass., Me., N. Y., Que.

Fenusa ulmi Sundewall

Fenusa ulmi Sundewall, Förh. Skand. Naturf., 1844, p. 249.
Messa alsia MacGillivray, Univ. Ill. Bull., vol. 20, no. 50, August 13, 1923, p. 22, ♀. *New synonymy.*

Status similar to above. Nearctic records: N. Y.

Fenusa alumna (MacGillivray) *new combination*

Messa alumna MacGillivray, Univ. Ill. Bull., vol. 20, no. 50, August 13, 1923, p. 23, ♀.
Messa amica MacGillivray, *ibid.*, ♀. *New synonymy.*
Messa appota MacGillivray, *ibid.*, p. 24, ♂. *New synonymy.*

Distribution.—Ill., Mass., N. H., N. Y.

Fenusa inspiratus (MacGillivray) *new combination*

Parabates inspiratus MacGillivray, Ann. Ent. Soc. Amer., vol. 2, no. 4, Dec., 1909, p. 264, ♀.

Male.—Similar in size, color and general structure to female. Genitalia with parapenes almost undifferentiated, fig. 17. Sagittae narrow and pointed at apex, volsellae digitate and rounded at apex, fig. 14. Penis valves wide, with two variable "horns" near apex, and no large, unpigmented area in central area, fig. 11.

Allotype.—Male; Hatchet Mt., Shasta county, Calif., July 14, 1933, on *Alnus*, K. A. Salman. Deposited in the U. S. National Museum.

Distribution.—Cala., Nev.

Fenusa anita (MacGillivray) *new combination*

Messa anita MacGillivray, Univ. Ill. Bull., vol. 20, no. 50, August 13, 1923, p. 23, ♀.

Male.—Similar in size, color and general structure to female. Genitalia extremely aberrant for both genus and subfamily. Parapenes large and plate-like, fig. 19. Sagittae and volsellae both enlarged and rounded at apex, fig. 16. Penis valves slender, straight, with a few minute setae at apex and a ventral membranous fringe, fig. 13.

Allotype.—Male; Montreal, Quebec, June 3, 1906.

Distribution.—N. Y., Que., Wis.

Fenusa lucifex n. sp.

This species most closely resembles *anita* (MacGillivray) but may be distinguished from that species by the black venter of the abdomen and the more slender antennae. From all members of the genus it differs in the smooth-lobed saw, fig. 4.

Female.—Length 3.5 mm. Color black, with the pronotum, tegulae and legs almost entirely yellow; legs with apices of their segments slightly infuscated; clypeus yellow with mesal fourth brown. Front wings fairly heavily infuscate with brown, hind wings only slightly so; stigma and veins brown.

General structure as for genus. Head robust, shining. Antennae slender, with first, second, fourth and fifth segments subequal, third twice length of each; flagellum filiform, closely set with apparent sense pores. Front wings with first abscissa of Rs and looped portion of 2A & 3A atrophied. Hind wings with apical portion of 2A almost atrophied, the loop connecting it with 1A reduced to a faint line. Abdomen shining. Sheath long, with ventral and dorsal margins parallel and straight, and apex diagonal. Saw, fig. 4, with 13 segments in lance, 12 in lancet, lancet with no teeth on lobes, forming a regularly serrate margin, ducts long and narrow.

Holotype.—Female; Fox Lake, Illinois, June 30, 1935, DeLong and Ross.

Notes on the European Starling in Illinois

Joseph B. Sommer
Peoria High School, Peoria, Illinois

ABSTRACT

In an attempt to investigate the possibility of the European Starling as a carrier of avian parasites from one poultry flock to another in Illinois, one hundred thirty-two (132) birds were examined during the months from September (1935) to January (1936).

Fifty-one of the Starlings examined were hosts to one or more cestodes (*Hymenolepis farciminosa* and *Rhabdometra nullicollis*), and three to Acanthocephala (*Mediorhynchus grandis*—Van Cleave). No evidence of the gapeworm (*Syngamus trachea*) so common to poultry was forthcoming.

A probable conclusion to this limited survey might suggest that the possibility of the Starling becoming a menace in carrying cestodes and nematodes to poultry flocks in Illinois, is at present, not very great.

The writer wishes to acknowledge the valuable assistance of Prof. Lyell J. Thomas, Department of Zoology, University of Illinois, and Dr. David H. Thompson of the State Natural History Survey, in this investigation.

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